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(54) **Method and apparatus for producing custom manufactured items.**

(57) Automated made-to-measure garment manufacturing method and apparatus. A subject's measurements are taken with a hand held measuring device and transmitted to a computer. The computer checks to see if the customer's style preference and physique are compatible and if they are, an order is generated. The customer measurements are then transmitted to a remote location for manufacture. At this location a computer has a set of co-ordinates defined for the customer's style in one size. These co-ordinates are modified based upon the actual customer measurements to produce a modified set of co-ordinates which in turn define the garment pieces for that customer. A control tape for a laser cutter is generated and the garment pieces are cut and sewn together. During the post cutting fabrication process, routing sheets for the garment indicate precision assembly steps to insure a quality finished garment is produced. Finally, the custom tailored suit is sent back to the retail outlet and delivered to the subject. Two embodiments of a measuring device used in the custom manufacturing process are disclosed. One takes only length measurements and a second takes both length and angle measurements. Each includes a frequency modulated transmitter for sending signals corresponding to the measurements to a separate receiver and storage unit where the measurements are stored for later use in the tailoring process. In a preferred embodiment of the invention, the storage unit comprises a personal computer with a visual display that can prompt a user into taking the measurements in a predetermined sequence.

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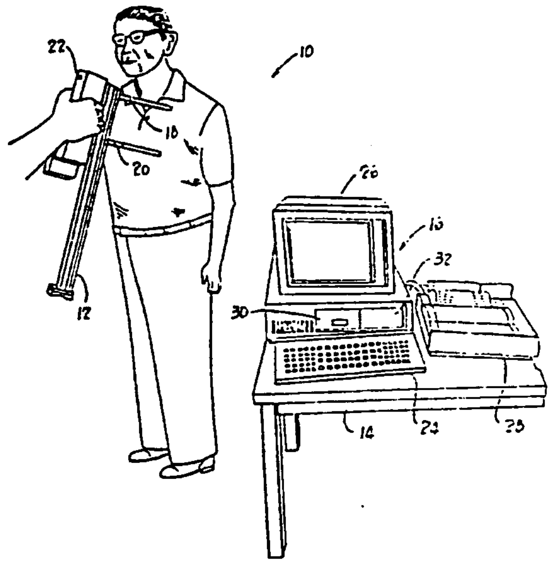

FIG.1

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Description

Method and Apparatus for Producing Custom Manufactured Items

The present invention relates to method and apparatus for producing custom manufactured items and has particular utility for producing individually tailored suits by cutting appropriately sized parts from a supply of fabric.

The garment industry has been slow in taking advantage of advances in technology to modernize its manufacturing operations. The techniques utilized in fitting a suit, for example, vary in only minor aspects from the techniques used 50 years ago. A person familiar with the suit making business in 1900 would not be unfamiliar with the techniques and machinery for producing suits in the 1980's. The reluctance to change by the suit manufacturing industry has placed those manufacturers operating where labor costs are high at a distinct competitive disadvantage in relation to manufacturers who have less expensive sources of labor available.

Traditional steps in tailoring a suit to a customer's specification have been inefficient for a number of reasons. The most widely practiced suit tailoring technique is familiar to anyone who has purchased a suit at a clothing store. The customer enters the store, approaches the rack where his or her size is located and looks over the suits available in that size. If the customer finds an appropriate suit, either a clerk or a tailor determines what alterations are needed to make the suit fit. Once the needed alterations have been determined by the tailor and/or clerk, and approved by the customer, the tailor can begin the task of altering the suit.

This off-the-rack method of suit tailoring causes inefficiencies which add to the cost of the suit. One inefficiency is the requirement that a large number of suits be stocked by the retail men's clothing store. To increase the odds that each customer entering the clothing store will find an appropriate suit, a wide variety of styles, patterns, and sizes must be on the rack so the customer may browse until he or she finds the right combination. The store must carry multiple versions of the same suit for the more popular styles. The result is a high overhead in inventory for the clothing store.

A second inefficiency caused by the off-the-rack method of suit selection is a waste in cloth. A man's suit will typically be made with a pair of pants which include enough material for a reasonably long legged individual, and in addition, will include enough material so that an individual can have cuffs added to the pants if he so desires. The waste in cloth for satisfying the added length requirement when multiplied over the millions of suits produced in accordance with the off-the-rack retailing technique is tremendous.

An additional inefficiency is the trend to produce three-piece, or vested suits for a high percentage of the suits of a given size. Many individuals rarely, if ever, use the vest which accompanies the suit which in every other respect is perfect for their needs. The suit manufacturer is wasting money since in all probability the sale could have been accomplished without the vest, and of course the customer has wasted money since he has paid for the vest which he rarely uses.

An additional disadvantage is that the store clerk may not be able to determine when a particular customer simply cannot wear a given style suit. The trained tailor could advise against a particular choice, but

the clerk may not recognize the difficulty and write up the order. The tailor may or may not recognize the difficulty in this style selection. If the tailor recognizes that these measurements and this style are not compatible, the customer will receive no suit and will have to begin the process of suit selection again. If the tailor does not recognize these limitations, the suit will be tailored but will end up looking and fitting poorly.

A second procedure which has received much less acceptance by the suit buying public is a mail order procedure where the customer takes his own measurements and mails them to a mail order house which tailors the suit to fit those dimensions and sends back a finished suit. This mail order technique has certain rather obvious deficiencies. The person taking the measurements is not trained so the measurements he provides the suit maker may be quite different from his actual measurements. If this is the case, the only remedy is to take the poorly fitted suit to a tailor who may or may not be able to remedy the problem.

The mail order procedure is also inefficient for the suit manufacturer. The manufacturer receives the measurements from the purchaser and then must cut and sew that suit. In the off-the-rack manufacturing process, multiple numbers of identical suits can be produced. In the mail order procedure, each cut of each piece requires individual attention. While, the mail order suit purchasing procedure cuts down on inventory, the cost of manufacturing increases.

One technological advance which has received surprisingly little acceptance in the suit manufacturing industry is the use of a laser cutter to cut out the suit pieces prior to sewing them together. The Hughes Aircraft Company laser cutting apparatus, for example,

has significantly increased the efficiencies with which suit parts can be cut from the original fabric. Thus far, however, the laser cutting technique has received limited acceptance perhaps because of the general tendency in the garment industry to avoid innovation and/or change.

Use of a laser cutting technique can reduce some of the manufacturing costs in producing off-the-rack suits. Whereas formerly each suit was individually cut from the fabric, the automation of the cutting process with the use of a laser allows continuous cutting of suits as well as enhances the quality with which various styles of suits can be made. The laser cutter, however, does not address the aforementioned inefficiencies with the off-the-rack suit manufacturing process. It is apparent, that if the manufacturers of custom made clothing are to effectively compete with manufacturers having a much cheaper source of labor while maintaining profit margins at an acceptable level, more automated manufacturing techniques as well as reductions in inventory costs are needed.

In accordance with the present invention, many of the inefficiencies noted above with respect to prior art manufacturing procedures are eliminated. Inventories and waste are reduced by use of a manufacturing process where items of apparel are made to measure for the customer. Rather than produce a high inventory of items which "approximately" fit the customer, the apparel items are cut and sewn together only after the purchaser's specifications have been analyzed and used to control the cutting of the item's constituent pieces.

In accordance with the invention custom manufacturing of an item of apparel is accomplished by first measuring a customer's body size and shape as well as

analysing the customer's style preferences. These steps will typically be performed at a retail outlet for the manufacturer. This information will be used to modify the measurements for the item and in particular will be used in generating a relative positioning of a number of pattern points for the pieces which, when assembled, make up the item.

Two embodiments of a measuring device are disclosed. In one, a first electronic measuring tape takes a length measurement using a measuring tape connected to a multi-turn potentiometer. As the user unwinds the tape the potentiometer turns and generates an analog output proportional to the length of tape unwound. A user actuated button on the side of the tape causes the potentiometer output to be converted into a communications signal for transmission to a receiver.

A second form of measuring device includes both a mechanism for taking a length measurement and also a mechanism for computing an angle of the device with respect to a reference orientation. The measuring mechanism is a set of calipers with one leg of the calipers coupled to a slide potentiometer that generates an analog output proportional to a length separation between the legs of the caliper. A plumb bob pointer mounted to the device is coupled to a rotatable potentiometer so that as the pointer rotates the potentiometer yields an indication of the tilt of the device with respect to the vertical.

The means for storing the measurements preferably includes a video display for prompting the user as to a sequence in which the measurements are to be taken. A measurement request is displayed on the screen, so that the person taking the measurements can position the measuring device in relation to a subject to take this measurement. When the user is satisfied that the hand held unit is properly positioned, he actuates a button——

which causes the length and in the second embodiment the angle measurement to be transmitted to the storage unit.

The invention has particular applicability to the manufacture of a custom tailored suit. The pattern points define the shape of the pieces included in the suit. By knowing the relative positioning of these pattern points, the pieces can be cut from a roll of material along specified lines defined by the pattern points. A more detailed description of the concept of pattern points will be disclosed in conjunction with a preferred embodiment of the invention. Once the modified position of the pattern points is known, the one or more pieces making up the garment are cut by an automated cutting machine, preferably a laser cutter, and then sewn together to produce the suit.

In accordance with a preferred embodiment of the invention, the re-positioning of the pattern points is accomplished by a programmable controller such as a computer. The computer generates control data which interfaces with a laser cutter controller so that during the cutting process the laser is cutting parts of custom made suits rather than the off-the-rack suits produced with prior art laser cutters.

There are significant advantages to the automated made-to-measure process outlined above. The retail outlets suit inventory is reduced. Various styles of suits will be included as well as various fabrics from which the customer can choose a suit, but the need for multiple suits of a given style as well as suits of every conceivable fabric are no longer necessary. Once a particular style and fabric suitable to the customer's needs is chosen, measurements are taken and used in manufacturing the suit.

As an adjunct to the reduction in inventory, waste in material and/or parts is avoided. If the customer has no desire for a vest with his suit, no vest is cut and both the customer and the manufacturer benefit.

The customer can order more than the standard number of items to the suit. An extra pair of pants with reversible vest to match that extra pair can be ordered and custom manufactured. A large variety of materials and styles is also available with no additional expenditure of retail space or inventory. This flexibility in choice, it is believd, will enhance customer satisfaction.

The disclosed invention has applicability for all shapes or sizes of people including situations where large modifications of an off-the-rack garment would be required. The measurements are taken, the pattern points generated, and the suit or other garment cut in exactly the same manner as a standard suit.

From the above, it should be appreciated that one object and advantage of the invention is a reduction in inventory and waste in the manufacture of items of apparel by implementing a made-to-measure manufacturing process utilizing an automated cutting mechanism controlled by a programmable controller. This and other advantages and features of the invention will become better understood when a detailed description of a preferred embodiment of the invention is described in conjunction with the accompanying drawings.

Figure 1 is a view of a subject being measured with a hand held measuring device that communicates with a unit for storing and interpreting the subject's measurements.

Figure 2 is a flow chart of an entire custom tailoring process of the invention.

Figure 3 is a flow chart of a portion of the Figure 2 process that is conducted at a retail outlet.

Figures 4A-4E define the steps of the custom tailoring operation at a factory having an automated cutting apparatus.

Figures 5A and 5B define an interpretation process for determining which model, size, and alterations of a particular style are best suited for a customer.

Figures 6A and 6B illustrate an example of the modification of pattern points of a garment.

Figure 7 shows three different garment patterns with pattern points modified for different customer measurements.

Figure 8 schematically illustrates a laser cutting station for cutting out garment patterns.

Figure 9 is a side elevation view of one embodiment of an electronic measuring device.

Figure 10 is an end elevation view of the Figure 9 device.

Figure 11 is a plan view of the Figure 2 device.

Figure 12 is an enlarged plan view of the hand held measuring device showing a detachable cross piece coupled to a caliper arm of the device.

Figure 13 is an enlarged elevation view of a movable arm forming one of two caliper arms on the Figure 2 measuring device.

Figure 14 is a sectional view taken along the line 14-14 in Figure 13.

Figure 15 is a partially sectioned view of an alternate embodiment of a hand held measuring device constructed in accordance with the invention.

Figure 16 is a view taken along the line 16-16 in Figure 15.

Figure 17 is a schematic block diagram of circuitry used with the measuring devices of Figures 9 and 15.

Figure 18 is a detailed electrical schematic of a transmitter interface portion of the Figure 9 device.

Figure 19 is a detailed electrical schematic of a transmitter interface for the Figure 15 device, and

Figure 20 is a detailed electrical schematic of a receiver interface for the hand held measuring device.

Figure 1 illustrates a retail setting 10 where an individual is being measured for a garment by a store assistant using a hand held measuring device 12. Supported on a table 14 is a storage unit 16 for storing measurements taken by the measuring device 12.

The hand held measuring device 12 is particularly adapted to aid one in taking measurements for use in tailoring an article of clothing or the like. The particular device 12 shown in Figure 1 has a mechanism for taking both a length and an angle measurement.

In operation, a user positions the measuring device 12 so that two caliper arms 18, 20 are positioned to measure a desired length separation on a subject and then actuates a pushbutton switch 22 on the unit. In response to this actuation, circuitry mounted inside the device 12 generates an electrical output corresponding to this length and also determines an angle the device 12 makes with the vertical and generates an electrical output corresponding to this angle. These outputs are converted into signals suitable for transmission to the storage unit 16 and sequentially transmitted to that unit.

The storage unit 16 preferably comprises a personal computer having a keyboard input 24, a visual display monitor 26 and a printer 28. The storage unit 16 also includes a central processing unit mounted to a motherboard as well as interface boards for coupling various

inputs to the motherboard. One interface board provides a coupling between the central processing unit on the motherboard and a floppy disk drive 30 which comprises one suitable mechanism for storing data from the hand held measuring device 12. In accordance with a preferred embodiment of the invention the storage unit 16 comprises an IBM (registered trademark) personal computer with a hard disk drive 32 that allows rapid data storage as well as a more permanent means of storing that data.

The computer prompts the user as to the proper procedures to take in performing the various measurements the device 12 is capable of taking. Thus, the operating system of the computer sequentially prompts via the display 26 the user as to which measurement is to be taken. The user then reorients the measuring device 12 to take the particular measurement and actuates the pushbutton 22 so that a length and angle measurement are automatically transmitted to the computer 16.

An alternate hand held unit 34 is illustrated in Figures 15 and 16. This unit 34 is strictly a measuring device for performing length measurements along a straight, curved, or zig-zagging direction. The user must therefore distinguish when a prompt appears on a screen 26 as to which of the two units 12 or 34 is to be used in taking a measurement. Each unit includes its own transmitter portion (to be described), whereas the storage unit 16 includes a single receiver responsive to transmissions from either of the two hand held units 12, 34.

Further details of the measuring device shown in Figure 1 are available by reference to Figures 9-14. These Figures show how two caliper arms 18,20 take a length measurement. A first of the two caliper arms 18 is fixed in relation to the measuring device 12 and extends at approximately right angles away from a ruler

42 which extends the length of the measuring device 12. A second of the caliper arms 20 is slidably mounted to the ruler 42 and its position can be adjusted so that the two arms 18,20 are separated by a particular length L of interest. Thus, in the Figure 1 illustration of the measuring device 12, the two arms 18,20 have been manually positioned so that the separation between the neck and chest is measured. To take the measurement, the user positions the device 12, adjusts the arm separation, and actuates the pushbutton 22. A manual measurement may also be taken by noting the separation distance between the arms.

At an end of the ruler 42 opposite the position of fixed caliper arm 18, is a contoured end piece 44 similar in shape to the arm support on a crutch. When an insleeve measurement is to be taken, the end piece 44 is positioned under the subject's arm and the movable or adjustable caliper arm 20 is moved along the ruler 42 until it is positioned next to the subject's hand where a coat sleeve would end. The user then actuates the button 22 and this measurement is automatically transmitted to the storage unit 16.

At the same end of the ruler 42 as the fixed arm 18 is a neck piece 46 that couples the ruler 42 to a handle 48 which the user grasps while positioning the measuring device 12. At the bottom of the handle 48 is located a protractor 51 including visible angle markings and a pivotally mounted pointer 53 for obtaining an angle measurement. As the measuring device 12 is oriented in relation to the subject, the pointer 53 is free to pivot thereby providing an indication of the device's orientation with respect to the vertical. These angles can be helpful in determining the posture of the subject. In Figure 1 when determining the length between the neck and chest position the pointer 53 pivots away from

its position shown in Figure 9 to yield an indication of the angle between the vertical and the orientation of the device 12.
This angle measurement is also transmitted when the user actuates the pushbutton 22. The user can also take a manual reading in the event the transmitter malfunctions by observing the pointer position with respect to the angle markings on the protractor. As seen most clearly in Figure 9, the protractor 51 and ruler 42 are separated by a gap 55 to allow the slidable caliper arm 20 to move continuously from a position next to the stationary arm 18 to the extreme opposite end of the ruler 42 next to the end piece 44.

Each of the caliper arms 18, 20 serves as a mount for one of two cross pieces 57, 59. During each of the measurements taken with the device 12 the cross pieces can either be positioned to aid in the length measurement or can be removed so that only the arms 18, 20 extend away from the ruler 42. In the Figure 1 measurement, the two cross pieces are shown in place but, for example, if the sleeve length were being measured, the cross pieces would be removed and only the caliper arms 18, 20 would be relied upon in positioning the device 12.

Details of the manner in which the cross pieces are mounted to the arms are illustrated in Figures 11 and 12. Each cross piece 57, 59 defines an elongated member having two notches 61 separated by a finger 63. The notches and finger are bound on either side by triangular shaped guide pieces 65 which are flush along the base of the the cross piece and which extend outwardly away from the cross piece to bound the finger 63 on either side.

Each of the caliper arms 18, 20 defines a notch 67 into which the finger 63 on the cross piece fits when

the cross piece is placed in position for measurement. Thus, the notch 67 and finger 63 in combination position the cross piece along one degree of linear movement and the two triangular guides 65 define the position of the cross piece in a perpendicular or orthogonal direction. The mating between cross piece and caliper arm is maintained by an interference fit between the two.

Figures 13 and 14 show details of the coaction between the movable caliper arm 20 and the ruler 42. The caliper arm 20 defines a through passage for the ruler 42 and includes a ridge or tongue 71 which mates with a groove defined by the caliper arm 20. Coupled to the caliper arm 20 are a pair of electrical contacts 73, 75 which ride against the ridge 71 extending along the length of the ruler 42. These electrical contacts 73, 75 provide an indication of the position of the movable caliper arm 20 in relation to the ruler 42.

The ridge 71 comprises two metallic elements separated by an insulator. One metallic element has a very low resistance and provides a ground for one of the contacts 75. A second metallic element has a uniform resistance per unit length and serves as a strip potentiometer. The second contact 73 rides on this strip and provides an indication of the resistance between the caliper arm 20 and the end of the ruler 42 near the neck portion 46. In this way the resistance separation between the two arms 18 and 20 is known and this resistance is converted into a voltage output via a simple voltage divider circuit where one leg of the voltage divider is the metallic strip.

When measurements are taken between the end piece 44 and the movable arm 20, the resistance is again used in calculating the distance between the two arms 18, 20 and this distance is subtracted (by the computer) from the distance between the stationary arm 18 and the end piece 44.

The second embodiment 34 (Figs. 15 and 16) of the measuring device includes a flexible measuring medium or tape 81 having a plurality of equally spaced markings extending along the medium to give a visual indication of length. The medium 81 is also coupled to a potentiometer 87 mounted inside the measuring device 34 which rotates with linear movement of the measuring tape 81. The particular potentiometer chosen is a twenty turn potentiometer which generates an analog output proportional to the length of movement of the tape 81.

The tape 80 is mounted to a tape take up reel 91 mounted to a potentiometer input shaft 93. The reel is biased to a position where a tape stop 95 contacts an outer surface of the measuring device 34 by a coiled spring 97. The spring 97 is coupled at one end to the potentiometer input shaft 93 and at an opposed end to a stationary anchor pin 99. As the tape 80 is withdrawn the spring is coiled thereby exerting a restoring force on the take up reel 91.

Turning now to the Figure 17 schematic, the circuitry for converting outputs from the hand held measuring devices 12, 34 into communications signals is illustrated. As noted previously, each of the measuring devices, i.e., the caliper arms 18, 20, the protractor 50, and the measuring medium 81 is coupled to its own potentiometer. These potentiometers have been designated with reference characters 83, 85, and 87 in Figure 17.

To illustrate the transmittal of this information to the storage unit 16, consider the example in which the hand held measuring device 12 is positioned next to the subject and the user wishes to store the relevant length and angle measurements indicated by the measuring device. The button 22 is actuated and a control unit 111 sequentially switches the analog output from the two potentiometers 83, 85 through an analog switch 113

to an analog-to-digital converter 115. In a preferred embodiment of the invention the control unit 111 directs the analog output from the second potentiometer 84 (coupled to the protractor) to the analog to digital converter 114 before the length measurement from the caliper arms.

At the analog-to-digital converter 115, the analog outputs from the potentiometers 83, 85 are converted into a 10 bit digital signal which is then transmitted to a universal asynchronous receiver/transmitter (UART) 117. The UART converts the data from parallel to serial format and transmits this data to an encoder 119 which generates a sequence of frequency modulated signals where the frequency of the signals indicates either a "one" or "zero" state. Thus, the encoder 119 converts the 10 bit signal sequence of ones and zeros from the UART into a frequency modulated sequence of signals. The encoder output is transmitted to a frequency modulated (FM) transmitter 121. The preferred transmitter is a commercially available FM transmitter from the Maxon Electronic Co. Ltd., 10727 Ambassador Dr., Kansas City, MO 64153. Other suitable transmitters are available and could be substituted for this transmitter. The transmitter 121 comes in a self contained package separate from a module (Figure 15) in which the A/D converter 115, UART 117, and Encoder 119 are packaged.

A Maxon receiver 123 coupled to the storage device 16 receives the frequency modulated output from the transmitter 121 and transmits this output to a waveform generator 125. The waveform generator converts the sinusoidal signal from the transmitter into a square wave signal which is transmitted to a filter unit 127. The filter 127 divides the square wave output from the waveform generator 125 depending upon the frequency of that output. The filter separates into two distinct paths, the "on" and "off" signals from the FM transmitter

121. These signals are routed to two inputs on a comparator 129 which only transmits the "on" or high outputs. These are in turn coupled to an optocoupler 131 which via a standard light emitting diode/transistor pair, transmits signals to a RS232 input 133 on the storage device 16. In this way, the analog output from the potentiometers is converted into a digital input at a standard RS232 interface for a personal computer. Computer software in the computer operating system monitors this input and converts the serial data into a representation of the analog output and stores this data in memory.

The operation of the potentiometer 87 coupled to the second embodiment of a hand held measuring device 34 is completely analogous with the exception that no analog switch is needed since the device 34 generates only one analog output from its potentiometer 86. The A to D conversion data encoding and transmission are in every other respect identical for the two units. Since the device 34 has its own separate circuitry for performing there functions, the hardware modules for the second hand held device 34 have been designated with prime (') reference numerals in Figure 17.

Figures 18-20 illustrate details of the circuitry schematically disclosed in Figure 17. The transmitter circuitry for the hand held unit 12 is disclosed in Figure 18. As seen in that figure, two inputs 149, 151 to the analog switch 113 are selectively coupled via an output 153 to the analog to digital converter 114. The part designation (4066) on the analog switch is for CMOS circuitry and is commercially available from a number of sources. The integrated circuits chosen for the preferred embodiment disclosed in Figure 11 are all identified with CMOS part numbers and were purchased from National Semi-Conductor.

Timing and control signals for the switch 113 are generated by the control circuit 111, which comprises three nand circuits 155, a single inverter circuit 157 and a band rate generator or clock 147. The circuitry illustrated requires a 5 volt DC energization signal, which is provided via a conventional 9 volt battery 145 (Figure 8) coupled to a voltage regulator (not shown) for producing a 5 volt signal. As seen in the Figure 11 representation, the nand gates 155 and inverter 157 each have a 5 volt input coupled to the output of this voltage regulator.

A power "on" switch 159, mounted to each of the hand held measuring devices 12, 34 provides this coupling and in addition provides a reset input to the UART 117. The switch 159 is a 3 position sliding switch, which the user slides to a reset position and then lets go so that the switch temporarily provides a reset to the UART and then slides back into its middle position in which the 5 volts from the voltage regulator is coupled to the various circuits shown on the diagram.

The push button switch 22 is coupled to the control circuit 111 so that each time this switch 22 is closed, the circuit 111 obtains the readings from the two inputs 149, 151 and transmits them to the digital to analog converter 115. This is accomplished via controlling the status of pin 5 on the analog switch 113.

The disclosed UART 117 can receive 8 bits of data at a time. The desired resolution of the present system, however, is 10 bits. To provide this degree of resolution, the system includes a multiplexer 161 to control switching of data to the UART. Under control of the control unit 111, the analog-to-digital converter 115 first passes 8 bits of the required 10 data bits data to the UART 117. Four of these bits are directly coupled from output pins on the analog to digital converter 115

to the UART 117, and four additional bits are coupled from the analog to digital converter through the digital multiplexer 161.

In a next time frame, the control unit 111 switches the digital multiplexer 161 so that two remaining bits from the analog to digital converter can be passed to the UART 117. The remaining six bits, which are passed in this second time frame, are redundant data and are stripped from the data stored by the storage unit 16. This is accomplished in software in the storage unit, rather than by the hardware of Figure 10.

The UART 117 generates an output at pin 25, which is a serial message corresponding to the parallel data input from the multiplexer 161 and the analog-to-digital converter 115. The output from the UART is coupled to pin 9 of the encoder 119, which converts the sequence of "on/off" pulses from the UART into a sequence of frequency modulated pulse. A zero or "off" logic state corresponds to a frequency of 1,200 hertz, and a one or "on" condition corresponds to a frequency of 2,400 hertz. The output from pin 1 of the encoder 119 is a series of these frequency modulated signals. This output is generally square-shaped, and is rounded by a filter 163, and attenuated by a voltage divider 165. The output from the voltage divider is coupled directly to input terminals of the Maxom transmitter 121.

Turning now to Figure 20, a receiver portion of the Figure 9 schematic is illustrated. The circuitry shown in Figure 20 includes an input 171 coupled to an output from the receiver 123. This input carries either 1,200 or 2,400 hertz signals from the receiver and passes those signals to an amplifier 173 and voltage limiter 175. In combination, the amplifier and limiter produce a square wave output from the approximately sinusoidal transmission from the receiver. This square wave output

is coupled to two filter units 177, 179. The first filter 176 transmits 2,400 hertz signals and attenuates the 1,200 hertz signal. The second unit 179 transmits the 1,200 hertz signal while attenuating the 2,400 hertz signal. Outputs from these two filter units 177, 179 are coupled to two inputs 181, 183 on the comparator 129. The comparator 129 passes the high frequency signal, but not the lower of the two frequencies. Stated another way, when the input 179 is high and the input 183 is low, an output 191 from the comparator is high, and when the opposite condition exists, the output 191 from the comparator 129 is low.

A high output from the comparator 129 turns on a transistor 185, which in turn causes current to flow through a light emitting diode 187. This light emitting diode 187 gives a visual indication as to when a transmission is occurring between the hand held unit 12 and the Maxon receiver.

When the transistor 183 conducts, a signal is coupled to the opto-coupler 131, which includes a second light emitting diode 187 and a phototransistor 189, which turns on in response to an output from the light emitting diode 187. When this transistor 189 conducts, an output to an RS232 connection goes to plus 12 volts and when a transistor 189 is not conducting, this output is at minus 12 volts. Thus, a series of either plus or minus 12 volt signals (corresponding to the zero and one state in digital format) is transmitted to an interface to the storage unit 16. Software in this unit stores the signals by converting them into data representations suitable for storing. Since the resolution provided by the measuring device 12 is 10 bits, the storage unit 16 utilizes two 8 bit bytes to store the information.

In the following discussion regarding the automated manufacturing of a garment, the modification of so-

called pattern points will be discussed in relation to a specific item making up a man's suit. This item will be the backpiece of a man's coat and in particular modifications to this backpiece as a result of variations in an individual's neck size will be discussed. It should be appreciated, however, that the modification of other pattern points in a man's suit are accomplished in a completely analogous fashion by the automated procedures to be described.

Turning now to Figure 2, the manufacturing process will be summarised and then broken down into specific components for a more detailed discussion. In Figure 2, the manufacturing process begins at a store location 10 (Figure 1) where a store assistant performs 50 a series of measurements on a subject. These measurements are transmitted to the storage unit 16 which as noted above comprises a personal computer.

The storage unit performs a so-called pre-interpreter process 52 which verifies 54 a possible fit based upon the style selected. This information is combined with the customer's material selection 56 and results in the generation of an order 58 which is transmitted to a manufacturing location or factory 60. The information in the order is a combination of the customer's measurements, the order makeup (vest, pants etc.), style and the desired material for the garment, customer information such as name, address etc. and the the results generated during the pre-interpreter step 52.

At the factory a final interpreter step 62 is performed which is analogous to the pre-interpreter step and will be described in detail below. At a next step 64 alterations in a standard suit size are made based upon the output from the final interpreter step 62. Once alterations have been performed and appropriate computer control data (such as a computer tape) genera-

ted at this step 64, laser cutting of the garment is performed 66. After the garment parts have been cut and tagged, assembly takes place 68 and finally the garment is transmitted to an inventory location 70 in preparation for shipment back to the store 10 where the customer picks up the completed garment.

An important step that takes place in the store 10 is the pre-interpreter step 52. The customer's measurements and his preferences in style are analyzed to determine whether that style selection can be used in fabricating the garment. This pre-interpretation step 52 takes place at the store 10 so that an order is not generated if a fit is not possible. This avoids the situation in which an order is placed and sometime later the customer informed that this was an inappropriate choice and the garment selection process must be repeated. Immediately after the measurement step 50, the customer can be informed whether or not his style preference can be fulfilled.

A second important feature of the invention worthy of emphasis is the alteration of the patterns at the step 64. A standard garment size is used as a starting point in this step. The garment designer generates the standard size for a particular style garment and pattern points that define this style are stored on computer. These standards are then used in generating altered pattern points which define the location of various cuts to be made by the laser cutting apparatus.

If an individual came into the store 10 and his measurements indicated that a garment corresponding exactly to the designer's original design would be appropriate, no alteration in the pattern points would be necessary and therefore during the final interpreter step 62 and alteration of pattern point step 64, a factory computer would determine that no changes would be

necessary and laser cutting would be performed using a setting of pattern points identical to the points resulting from the designer's original work. Typically, of course, the pattern points for any individual must be altered to some extent before laser cutting.

Many of these steps in the present invention are performed by computer, either the computer 16 at the store location, or a larger computer at the factory 60. The steps in performing the pre-interpreter 52 and final interpreter 62 process are similar.

The pre-interpreter process 52 is summarised in Figure 3. As noted above, the pre-interpreter utilises measurements 110 taken by the store assistant. These measurements are stored in the memory of the storage units 16. As a first step in the pre-interpretation process the measurements are combined 111 with information regarding the customer's order data and preference data. The computer then performs verification steps 112, 114, 116 to determine that the measurement information, order information and preference information is valid.

Once a determination is made that this information is valid, the in-store interpreter combines this information at a step 118 to make a determination 120 whether the customer's preferences and measurements are compatible. If the answer to this question is no, a rejection flag 122 is set and saved 124 on the floppy disk storage unit 30. A customer data disk 126 has been schematically illustrated in Figure 3 to indicate a permanent record of this rejection is maintained at the store 10. If a fit is possible, an acceptance flag is set 128 and in a similiar fashion, this information is stored on the floppy disk 126.

The information is stored regardless of whether a fit is possible. A file is therefore created for each customer whose measurements are taken utilising the

hand held measuring device 12. This information is sent to the manufacturer and can be accessed as needed.

The rejection data can be useful in the business planning of the garment manufacturer. If enough people need a particular modification to a given style and that modification cannot be accommodated by the disclosed process, it behooves the manufacturer to create that style or allow an existing style to be modified to meet the customer's needs. Thus, if a significant percentage of customers are rejected for the same reason after selecting a particular style, modifications can be made in the style to accommodate those customers.

If an order is placed, the computer 16 next prints 130 the customer data and invoice information. This printing step involves separate generation of a customer data report 132 and generation of a customer in-store invoice 134.

This process continues until the end of the business day. If the computer decides 136 that the end of the day has not been reached, the pre-interpreter 52 returns to the start of the algorithm described in Figure 3 and subsequent measurements for other customers are taken.

A communications link (not shown) between the store computer 16 and a factory computer is maintained either along a dedicated link-up or alternately over the public telephone system with the use of a modem. The factory computer is responsible for generating a control tape used by a separate factory computer 138 (Figure 8) in controlling a laser cutter 139. The factory computer begins the process of generating a control tape by retrieving customer information at a step 140 in Figure 4A. At this step, customer data from the floppy disk 126 at the store location is transmitted to the factory computer and this information is transmitted at a step 142 to a customer file 144 maintained on a hard disk

unit forming part of the factory computer system. This information as well as being stored in non-volatile format, is loaded into the computer for utilization in a factory interpreter algorithm 146. This algorithm utilizes model specifications stored on a disk 148 to make a determination 150 regarding the best model fit for a customer's body type.

At a next step 152 in the process the computer compares the model specifications with the customer measurements to determine alterations in the model specifications to fit the particular customer. This alteration or delta information is stored on the customer order file 144. As a final step in the factory interpreter process, the computer prints 154 an interpretation report 156 for future reference.

Figure 4B schematically illustrates the steps in modifying the pattern points based upon the interpretation process 62. The pattern is altered before any laser cutting can be performed. Each garment includes a number of different patterns which are sewn together to produce that garment. The reference or pattern points are stored on a pattern file 160 which are repeatedly accessed by the computer in modifying the pattern points.

A first pattern is taken to size 162 and a number of pattern points altered 164 until a determination 166 is made all pattern points for a particular pattern have been altered. Details of this alteration process for one pattern, the back piece for a man's suit, are described below in conjunction with Figures 6A and 6B. Once all alterations for a particular pattern have been made, the computer loads 168 the altered pattern points for a particular pattern into a marker file 170. Once a particular pattern has been modified, a test 172 is made whether all patterns for a particular garment have been adjusted. If all garments have been adjusted, a

routing sheet 174 for that garment is printed 176. If all patterns have not been modified, the computer returns to the beginning 162 to access the next set of pattern points from the pattern file 160.

Subsequent to the printing of the routing sheet 174, the modified patterns stored in the marker file 170 are utilized to layout 178 the garment on a cathode ray tube. This layout corresponds to pattern arrangement from a web of material. The process of building these markers 178 involves an operator sitting in front of a cathode ray tube and moving the patterns for a particular garment to a screen area that represents the material. As the operator arranges the patterns the arrangement is stored by the computer and used to generate a control tape for the laser cutter 139. Alternately, the process of marker generation can be accomplished automatically by a computer program.

Figure 4C summarizes bookkeeping steps that must be performed prior to laser cutting. As a number of garments are cut in sequence, a plan or order 180 of cutting must be determined. As this plan or order is being determined, a determination must also be made concerning the amount of materials required by the laser cutter. This determination 182 utilizes a material file 184 and results in the printing 186 of a material requirements report 188. Once the cut plan 180 for a number of garments has been determined, it is possible to generate 190 a control tape 192 for the computer 138 to control laser cutting of a number of garments. At the same time the control tape 192 is generated, a materials cut plan report 196 is generated indicating the sequence and timing of laser cutting.

A laser cutting station 194 is illustrated in Figure 8. A roll 195 of fabric 197 is unwound and moved by a conveyor 198 beneath the laser cutting 139 at a controlled

rate. The computer 138 responds to the control tape 192 and directs the cutter 139 to cut patterns from the fabric 197. Subsequent to laser cutting of the fabric a number of manufacturing steps (Figures 4D and 4E) are monitored and controlled. Prior to discussing these steps, however, details of the interpretation process 150 and pattern alteration process 164 are described.

Turning now to Figures 5A and 5B, the details of the interpretation process 150 used to choose the best model in a subject's style choice are schematically disclosed. As a first interpreter step 210, the computer accesses model specifications stored on a disk storage 148. The interpreter determines 212 what size the customer needs based upon the measurements and adds or subtracts 214 increments to the master model specifications stored on disk 148. This addition or subtraction is required for a suit, for example, if the customer measurements call for anything other than a size 40 regular. At a next step 216, minimum and maximum values are determined for each of the measurements for the particular size the customer needs. Also at this step an ideal value for each measurement is determined.

At a next step 218, a customer ease is added to a particular customer measurement. This ease factor is the amount a customer measurement must be incremented to give the ideal garment measurement. At a next step the customer ease measurement is compared 220 to the model minimum and maximum values. If the customer measurement including ease is within the minimum or maximum value, the garment need not be altered based upon this measurement. Each measurement in turn is compared in this way until all measurements have been compared with the minimum and maximum values.

If a particular measurement is not within the minimum and maximum values, an alteration delta is generated

224 and this delta factor is compared 226 with alteration limits. If this change or delta is within limits, this alteration delta is stored 228 in memory 229. If it is not within limits, the alteration change is modified 230 to be within the alteration limits and then stored 228. Eventually, either each measurement will have been seen to be within the minimum and maximum value and therefore no change in that measurement is needed or an alteration delta will be generated for that particular measurement.

Once it is determined 232 that all measurements have been analyzed, specifications for a different model are accessed 210 by the interpreter and the same process performed for each of the measurements for that particular model. In a preferred embodiment, four different models are analyzed for each style. One of these models produces the best fit for that customer's measurements. The model that produces that best fit is used to manufacture the garment. The customer knows that the suit corresponds to a particular style but does not know which model among the four possible choices for a particular style the computer will choose in matching his or her style preferences with his or her unique measurements. The optimum model choice depends on how many measurements are beyond the minimum/maximum values as well as the size of the alteration deltas generated for each of the multiple models.

Turning now to Figures 6A, 6B and 7 the modification or alteration 164 of the reference points for a particular pattern will be discussed in conjunction with a specific example. This process takes place after a particular garment model has been choosen. The specific example discussed is the modification of the back pattern 310 (Figure 7) for a man's suit based upon variations from a normal neck dimension.

At the beginning of the Figure 6A procedure a point reference array 352 is initialized 312. Each of approximately seventy points that define the back pattern 310 has an entry in a point attribute array 314 which tells what position in the point reference array that point occupies. This position is extracted 316 so that the point reference array is filled with the reference numbers of each of the seventy points.

Each pattern has a ten digit pattern number 320 with the last three digits corresponding to a part number. To be more specific, in the back pattern number the part number can refer to either the cloth back (pattern 011) or one of two (patterns 001, 002) linings for the back. Based upon this part number, certain critical points of the pattern are defined and extracted 353 from the point reference array 352.

Returning to the backpiece example, the critical points for both the cloth back and lining are the blade 354, shoulder 356, neck 358, and center seam 360 points (Figure 7). A pattern co-ordinate array 362 stores the X and Y co-ordinates for each of the points which define a particular pattern and size. Stated another way, the backpiece for a 44 normal (for example) has 70 pattern points to define the backpiece of Figure 7. The X-Y co-ordinates for these 70 points is stored in the pattern co-ordinate array.

The Figure 6A algorithm saves 364 the neck and shoulder point co-ordinates by ascertaining the position of these points from the point reference array 352 and then changes 366 the Y co-ordinate (see Figure 7) of each of the pattern points between the neck point and the shoulder point inclusive by an alteration or delta factor 368 based upon the subject's neck dimension. This results in a shift to the right (small neck) or left (large neck) of the curve 369 between the shoulder

356 and neck point 358. These altered point co-ordinates are saved in the pattern co-ordinate array 362.

A parameter array is then filled 370 from the co-ordinants of the points defining the old neck hole curve 372 and the new and old end points 358, 360 for the neck hole curve. A reshaping subroutine 374 reshapes the neck hole 372 and fills in co-ordinates for the new pattern into the parameter array. This reshaping is based upon an approximation method using derivatives (slopes) of the old curve and the new or altered end-points. As a next step the parameter array co-ordinates are transferred 375 back to the pattern array 362 and define the altered pattern.

At a next step the co-ordinates for the original armhole curve 376, and the end points 354, 356 for the new and old armhole curve are entered 378 into the parameter array and the reshaping subroutine 374 modifies the co-ordinate points along the armhole 376. Finally the new armhole co-ordinates are transferred 380 from the parameter array to the pattern array 362. A modification in the back based upon neck size is complete and the computer goes on to make modifications based upon other measurements for other patterns until the pattern points for the entire garment have been altered. This data is all stored and is represented by the patterns presented to the CRT operator who builds 178 the material cut arrangements. The altered patterns then, of course, become embodied in the computer control tape 192.

Figures 4D and 4E schematically illustrates post-laser cutting procedures utilized in the automated garment manufacturing process. At this stage of fabrication, a number of garment pieces have been cut using the laser cutter and these pieces are ticketed or marked 410 and sent 412 to appropriate locations for sewing. Routing sheets 174 are generated to indicate the particular path a garment pattern must follow.

The routing sheets 174 contain control data used in the manufacture of.the garment. This control data is used to ensure the proper and precise assembly of the garment since each garment is unique and requires different handling during assembly.

The control data is any information needed for the precise assembly of a garment. This data can be anything as specific as the proper positioning of a pocket or button to something as general as whether or not to edge stitch the lapel or a specific way the finished garment needs to be pressed.

The control data also includes finished dimensions of the garment. These dimensions are used for quality control during the various phases of the manufacturing process. This control data can be in either a printed form for manual assembly or in a numeric control form for automated assembly.

After the routing sheets are generated the remaining steps 416-438 in Figures 4D and 4E are performed. Briefly, each of the parts or patterns goes to its respective sewing shops where parts are sewn together and sent to a stockroom (Figure 4E) where all the garment components (jacket, pants, vest, etc) are matched 434 together. The garment is then shipped 437 back to the store and delivered 438 to the customer.

It should be noted by referring to the steps 424, 428, 429 where garment patterns are sewn together, the term precision is used. This term is required in the fabrication process since it would be counter productive for the precision alteration of the various pattern points to be performed under computer control, first in the generation of the control tape and secondly in the laser cutting and then lose this precision by sloppy sewing at the sew shops. If the suit or other garment is made to fit the customer with the aid of the computer,

the sewing steps 424, 428, 429 must be precisely carried out with the highest standards of quality control maintained.

The generation 435 of a daily shipping list is in conformity with the automated steps described above. When the subject's measurements are taken, that subject is promised a suit on a given delivery day which is coordinated with the back log of orders at the factory. The shipping list generated at the stage 435 after the garment components have been assembled in the stockroom, is based upon that earlier order information and unless production has fallen behind for a legitimate reason the two dates should match.

The disclosed invention has been described with a degree of particularity. The choice of computer system and measuring devices for both retail and factory locations is based upon the memory and storage requirements of the manufacturing system. As business needs dictate, this computer system choice can be modified. The manufacturing process need not be limited to a men's suit although certain ones of the manufacturing steps have obviously been described in relation to a man's suit.

CLAIMS:

1. Apparatus comprising:

a measuring device for taking a length measurement;

means mounted to the measuring device for converting an indication of said length into a communications signal;

remotely positioned receiver means for receiving said communications signal and converting said communications signal into an electrical signal; and

means for storing said length measurement as indicated by said electrical signal.

2. A method for taking measurements in tailoring an article of clothing comprising the steps of:

aligning a measuring device next to a subject, said measuring device including means for taking a length measurement,

transmitting a signal corresponding to said length measurement to a receiver,

storing said length measurement in a storage means for later access during tailoring of an article of clothing.

3. The method of claim 2 said storage means prompts a person taking the measurements as to a sequence in which to take those measurements.

4. The method of claim 2 additionally comprising a step of measuring an orientation of said measuring device with respect to a reference orientation.

5. A measuring device comprising:

a ruler and a set of two caliper arms with one of said arms fixed with respect to said ruler and a second of said arms slidably mounted to said ruler for movement along a length of said ruler,

means for sensing a separation between said arms; and

means for sensing an orientation of said device as the separation is sensed.

6. The measuring device of claim 5 wherein the means for sensing a separation comprises an elongated metal strip mounted to said ruler and contacts mounted to said second arm, said strip and contacts forming a potentiometer for measuring the resistance of a portion of said strip between said two caliper arms.

7. The measuring device of claim 5 wherein said means for sensing an orientation comprises a pointer pivotally mounted to said device and a rotatable potentiometer coupled to said pointer to sense changes in orientation of said pointer and produce an electrical output related to said orientation.

8. The measuring device of claim 5 additionally comprising means for digitizing said first and second signals, encoding said digitized signals into a frequency modulated sequence of pulses and transmitting said frequency modulated sequence to a receiver for storage of said angle and length measurement.

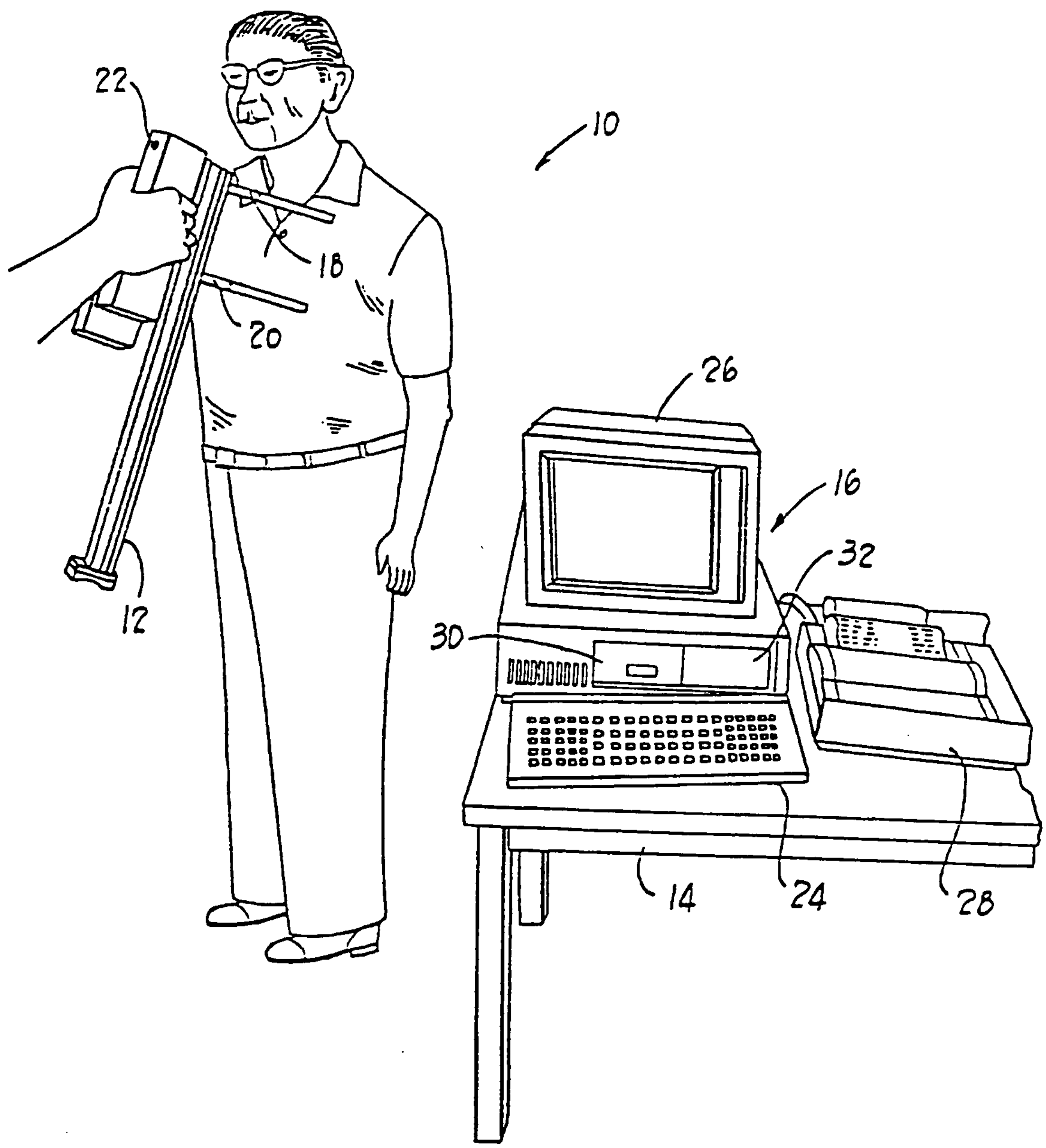
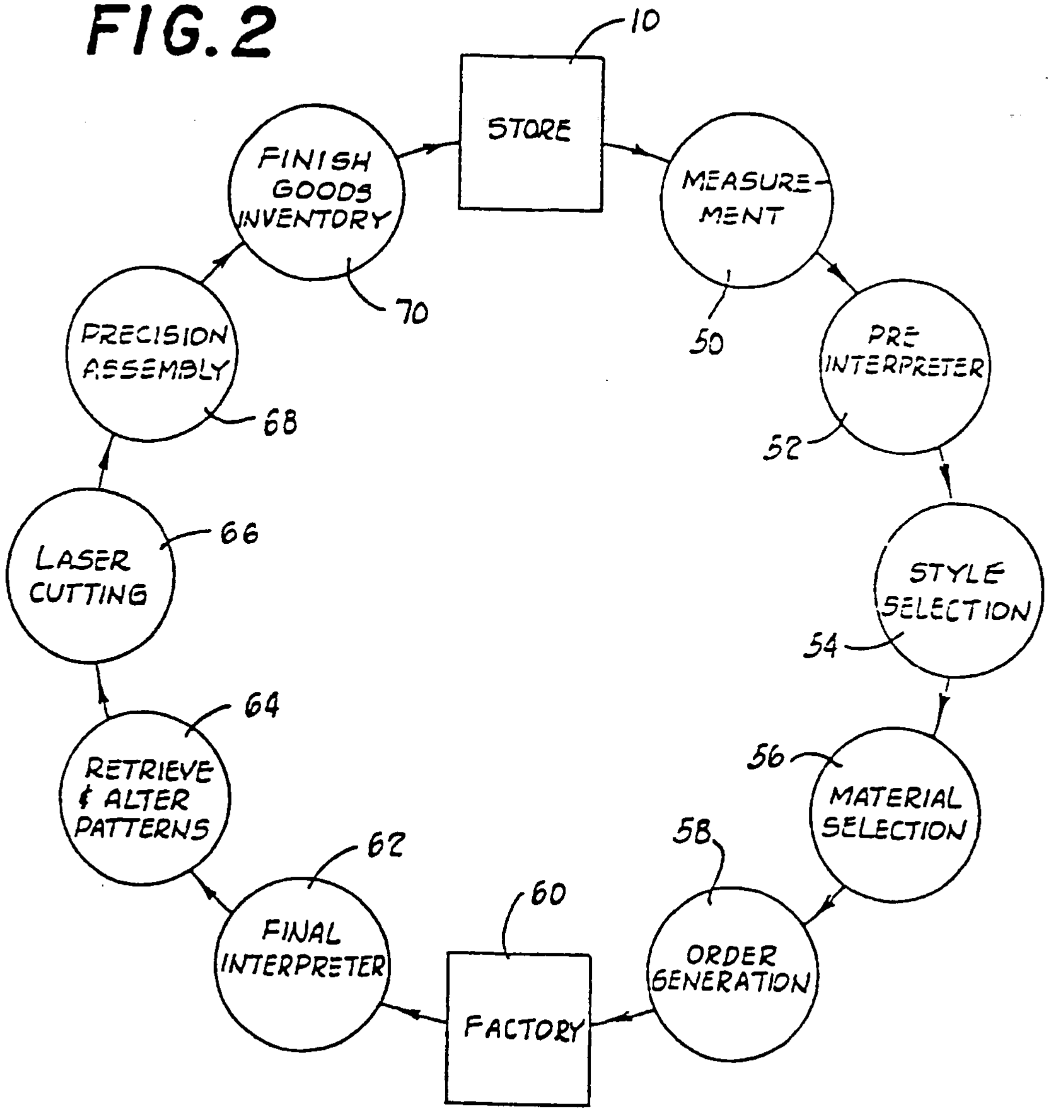


FIG.1

FIG. 2


STORE
10
MEASUREMENT
50
PRE INTERPRETER
52
STYLE SELECTION
54
MATERIAL SELECTION
56
ORDER GENERATION
58
FACTORY
60
FINAL INTERPRETER
62
RETRIEVE & ALTER PATTERNS
64
LASER CUTTING
66
PRECISION ASSEMBLY
68
FINISH GOODS INVENTORY
70

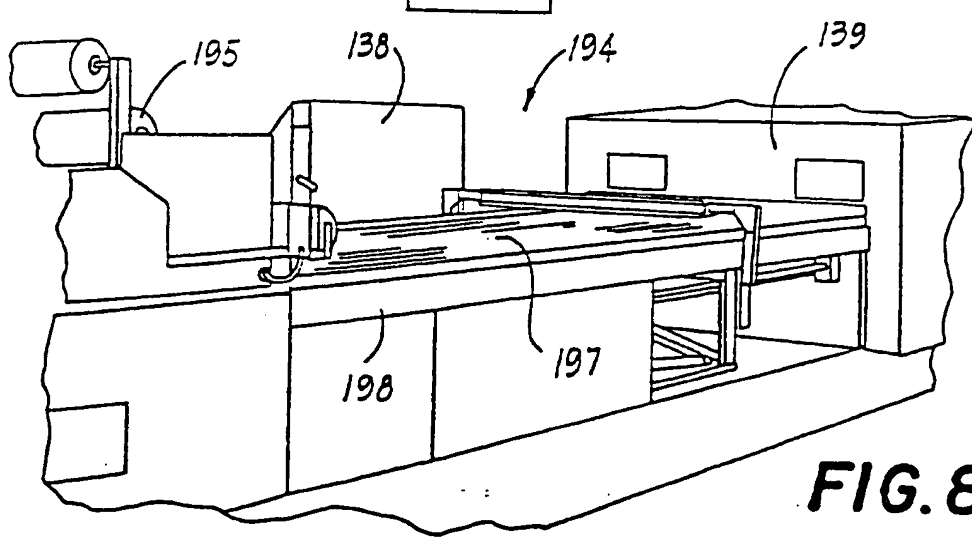

195
138
194
139
198
197

FIG. 8

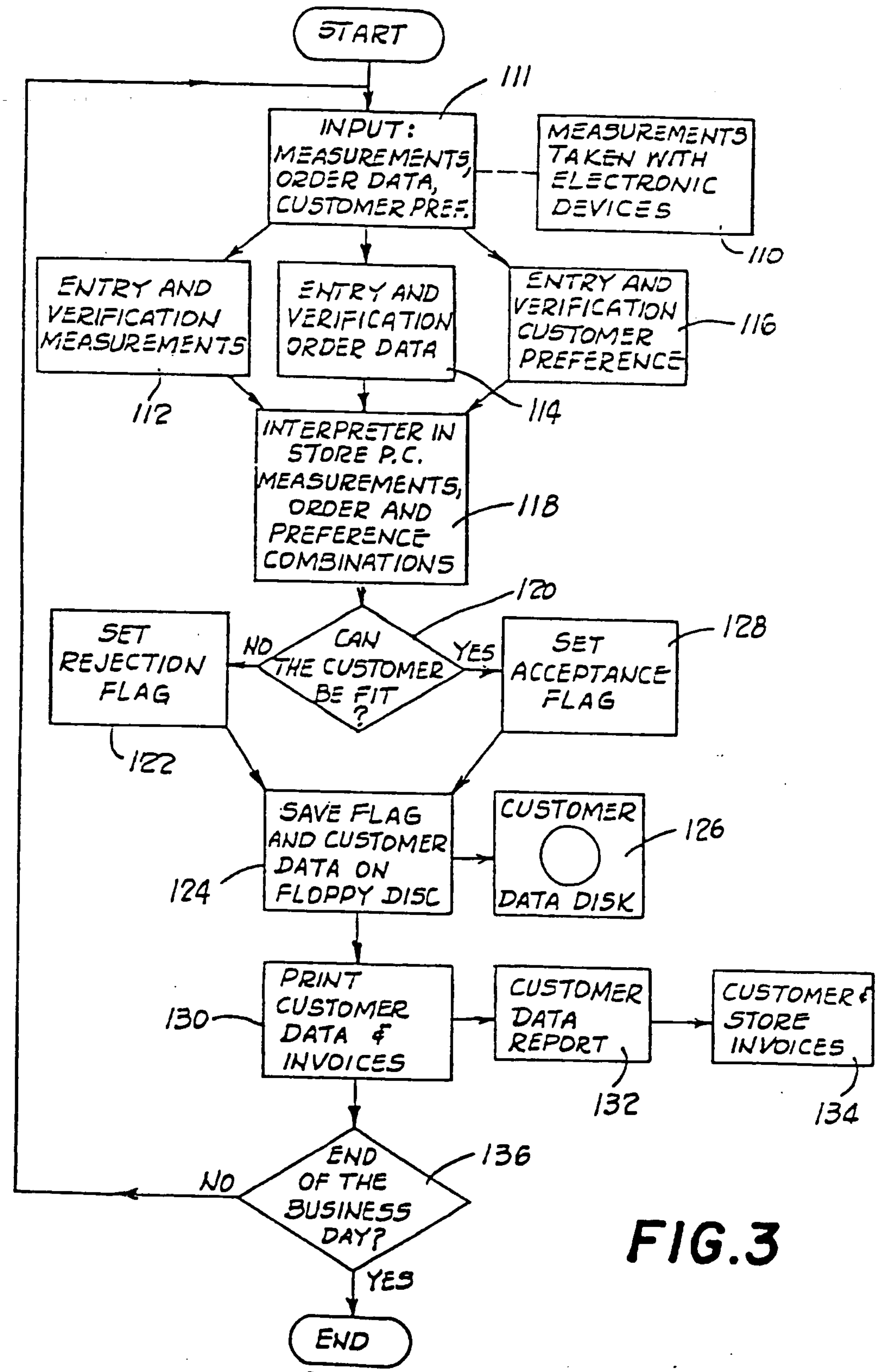

START
INPUT: MEASUREMENTS, ORDER DATA, CUSTOMER PREF.
111
MEASUREMENTS TAKEN WITH ELECTRONIC DEVICES
110
ENTRY AND VERIFICATION MEASUREMENTS
112
ENTRY AND VERIFICATION ORDER DATA
114
ENTRY AND VERIFICATION CUSTOMER PREFERENCE
116
INTERPRETER IN STORE P.C. MEASUREMENTS, ORDER AND PREFERENCE COMBINATIONS
118
CAN THE CUSTOMER BE FIT ?
120
NO
YES
SET REJECTION FLAG
122
SET ACCEPTANCE FLAG
128
SAVE FLAG AND CUSTOMER DATA ON FLOPPY DISC
124
CUSTOMER DATA DISK
126
PRINT CUSTOMER DATA & INVOICES
130
CUSTOMER DATA REPORT
132
CUSTOMER & STORE INVOICES
134
END OF THE BUSINESS DAY?
136
NO
YES
END

FIG.3

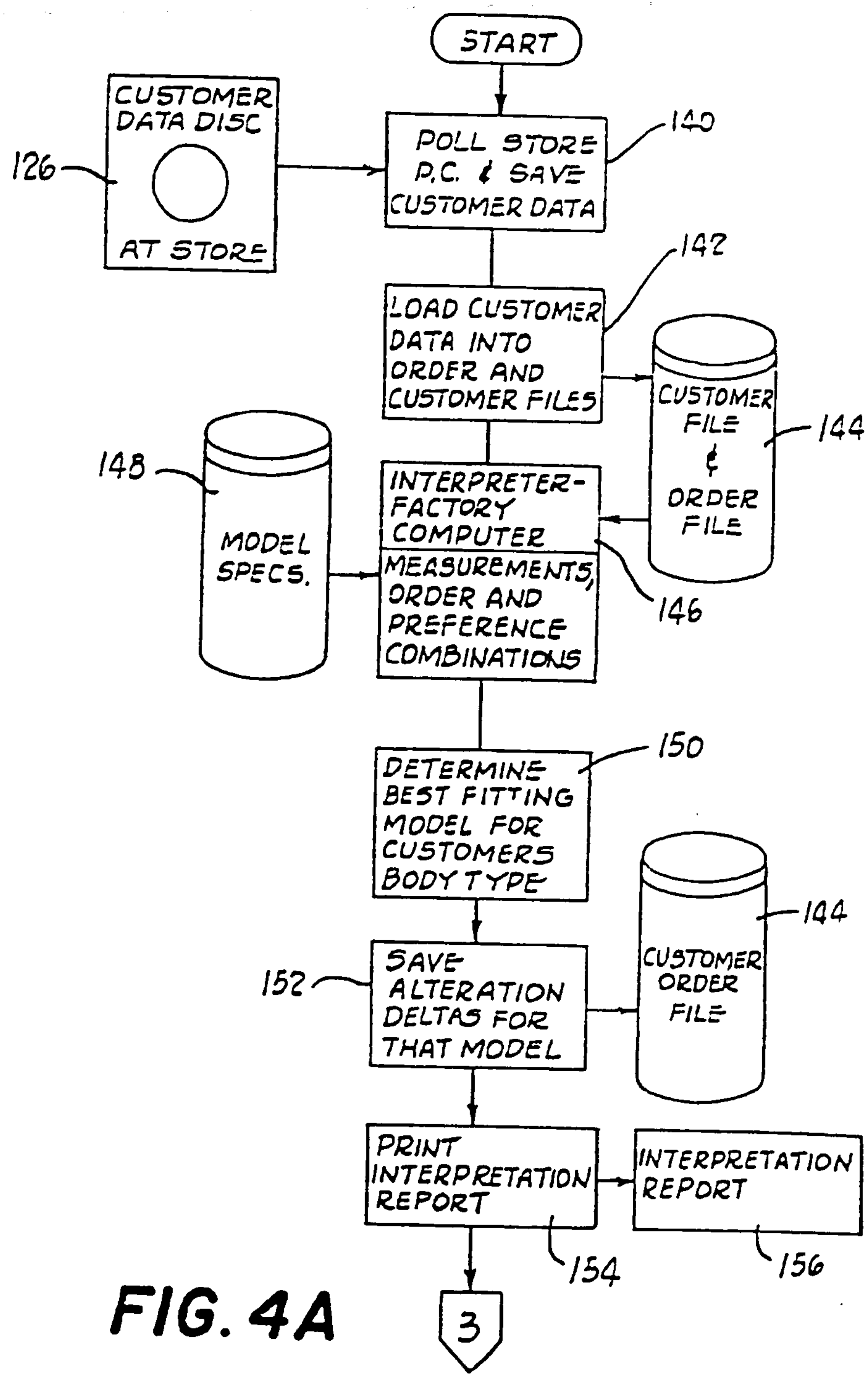

START
CUSTOMER DATA DISC
AT STORE
126
POLL STORE P.C. & SAVE CUSTOMER DATA
140
LOAD CUSTOMER DATA INTO ORDER AND CUSTOMER FILES
142
CUSTOMER FILE & ORDER FILE
144
148
MODEL SPECS.
INTERPRETER-FACTORY COMPUTER
MEASUREMENTS, ORDER AND PREFERENCE COMBINATIONS
146
DETERMINE BEST FITTING MODEL FOR CUSTOMERS BODY TYPE
150
CUSTOMER ORDER FILE
144
152
SAVE ALTERATION DELTAS FOR THAT MODEL
PRINT INTERPRETATION REPORT
INTERPRETATION REPORT
154
156
3

FIG. 4A

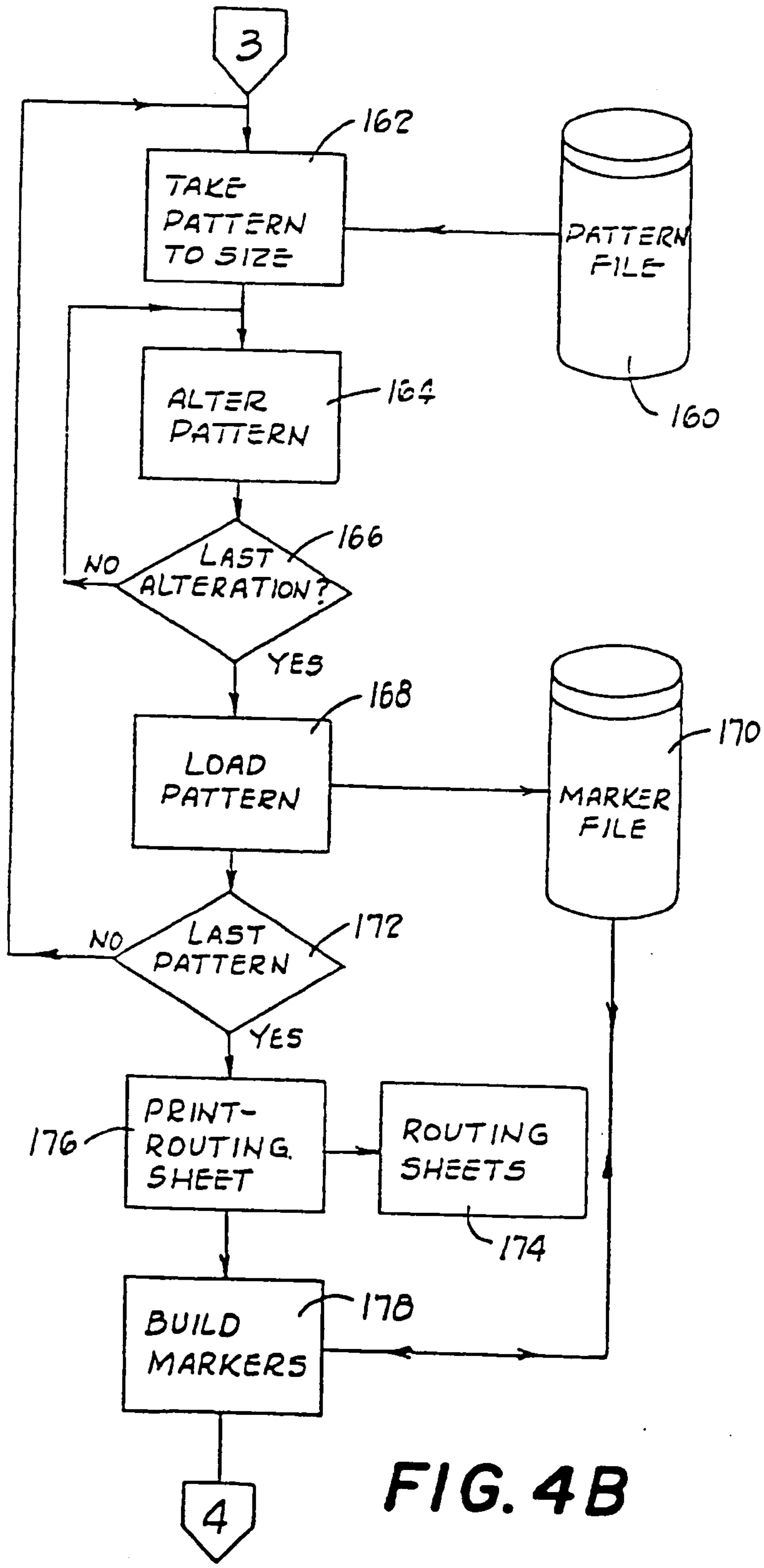

3
TAKE PATTERN TO SIZE
162
PATTERN FILE
160
ALTER PATTERN
164
LAST ALTERATION?
166
NO
YES
LOAD PATTERN
168
MARKER FILE
170
LAST PATTERN
172
NO
YES
PRINT-ROUTING SHEET
176
ROUTING SHEETS
174
BUILD MARKERS
178
4

FIG. 4B

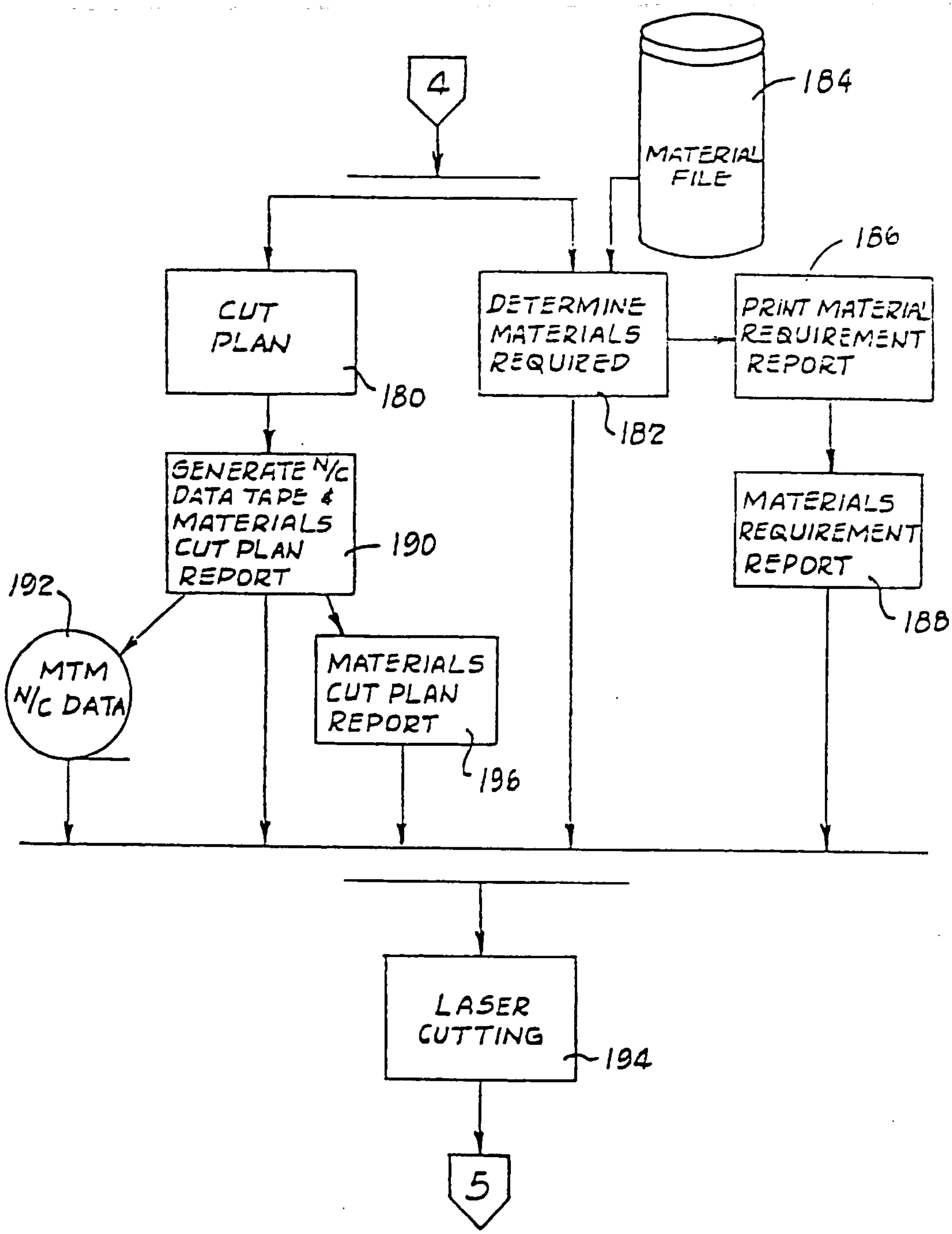

4
MATERIAL FILE
184
CUT PLAN
180
DETERMINE MATERIALS REQUIRED
182
PRINT MATERIAL REQUIREMENT REPORT
186
GENERATE N/C DATA TAPE & MATERIALS CUT PLAN REPORT
190
MATERIALS REQUIREMENT REPORT
188
192
MTM N/C DATA
MATERIALS CUT PLAN REPORT
196
LASER CUTTING
194
5

FIG.4C

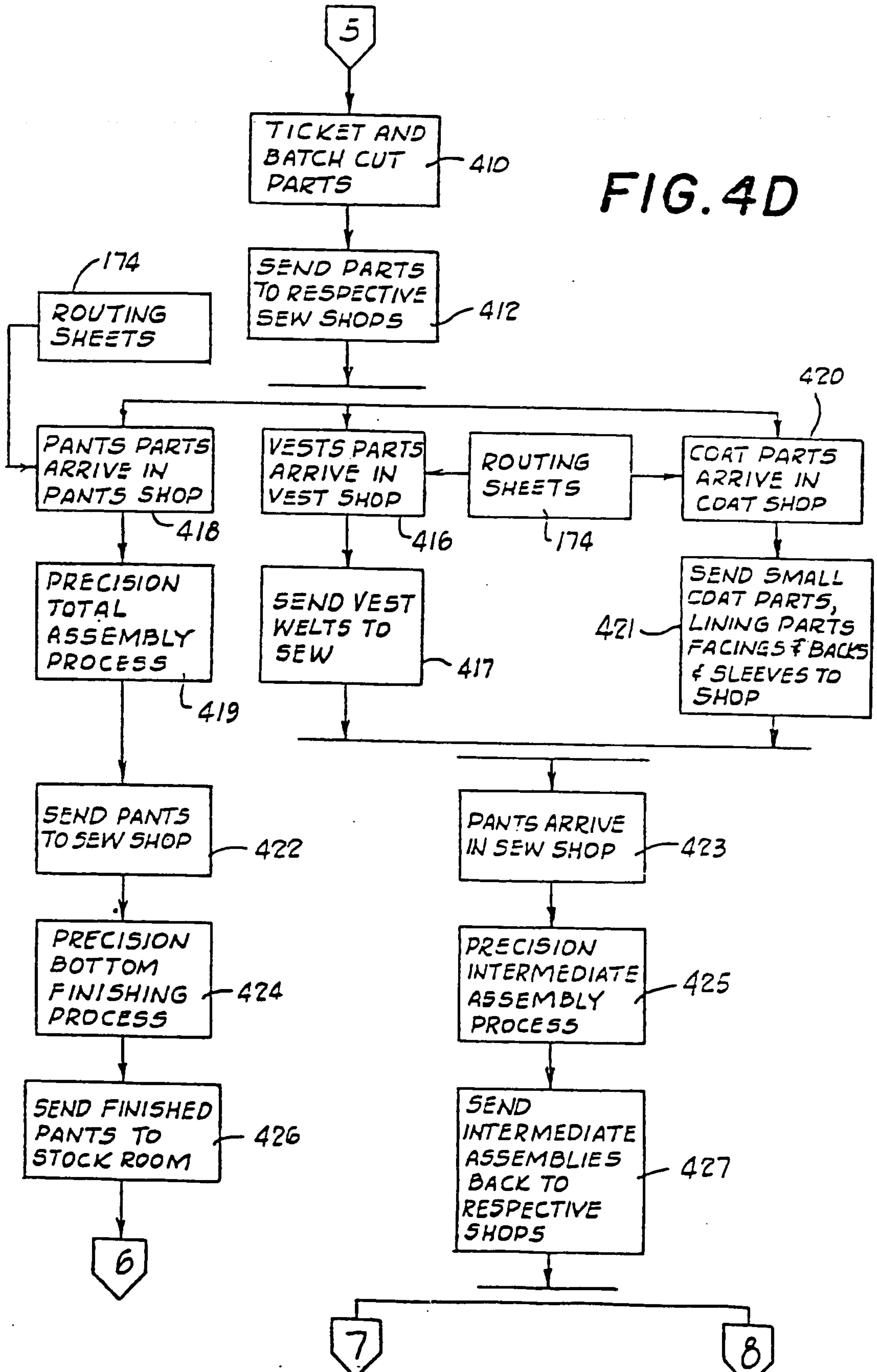

5
TICKET AND BATCH CUT PARTS
410
SEND PARTS TO RESPECTIVE SEW SHOPS
412
174
ROUTING SHEETS
420
PANTS PARTS ARRIVE IN PANTS SHOP
418
VESTS PARTS ARRIVE IN VEST SHOP
416
ROUTING SHEETS
174
COAT PARTS ARRIVE IN COAT SHOP
PRECISION TOTAL ASSEMBLY PROCESS
419
SEND VEST WELTS TO SEW
417
421
SEND SMALL COAT PARTS, LINING PARTS FACINGS & BACKS & SLEEVES TO SHOP
SEND PANTS TO SEW SHOP
422
PANTS ARRIVE IN SEW SHOP
423
PRECISION BOTTOM FINISHING PROCESS
424
PRECISION INTERMEDIATE ASSEMBLY PROCESS
425
SEND FINISHED PANTS TO STOCK ROOM
426
SEND INTERMEDIATE ASSEMBLIES BACK TO RESPECTIVE SHOPS
427
6
7
8

FIG. 4D

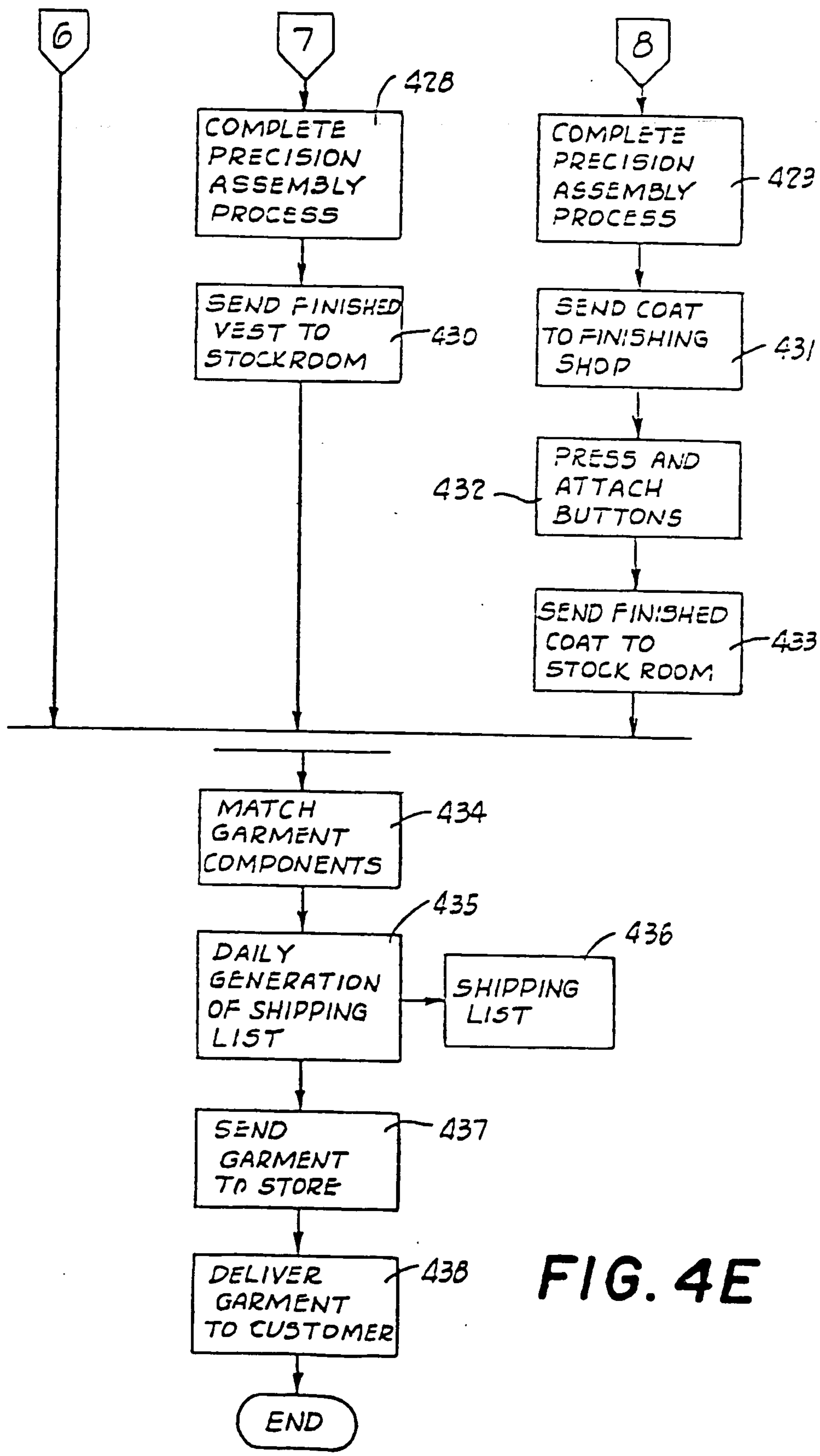

6
7
8
428
COMPLETE PRECISION ASSEMBLY PROCESS
COMPLETE PRECISION ASSEMBLY PROCESS
429
SEND FINISHED VEST TO STOCKROOM
430
SEND COAT TO FINISHING SHOP
431
432
PRESS AND ATTACH BUTTONS
SEND FINISHED COAT TO STOCK ROOM
433
MATCH GARMENT COMPONENTS
434
435
DAILY GENERATION OF SHIPPING LIST
436
SHIPPING LIST
SEND GARMENT TO STORE
437
DELIVER GARMENT TO CUSTOMER
438
END

FIG. 4E

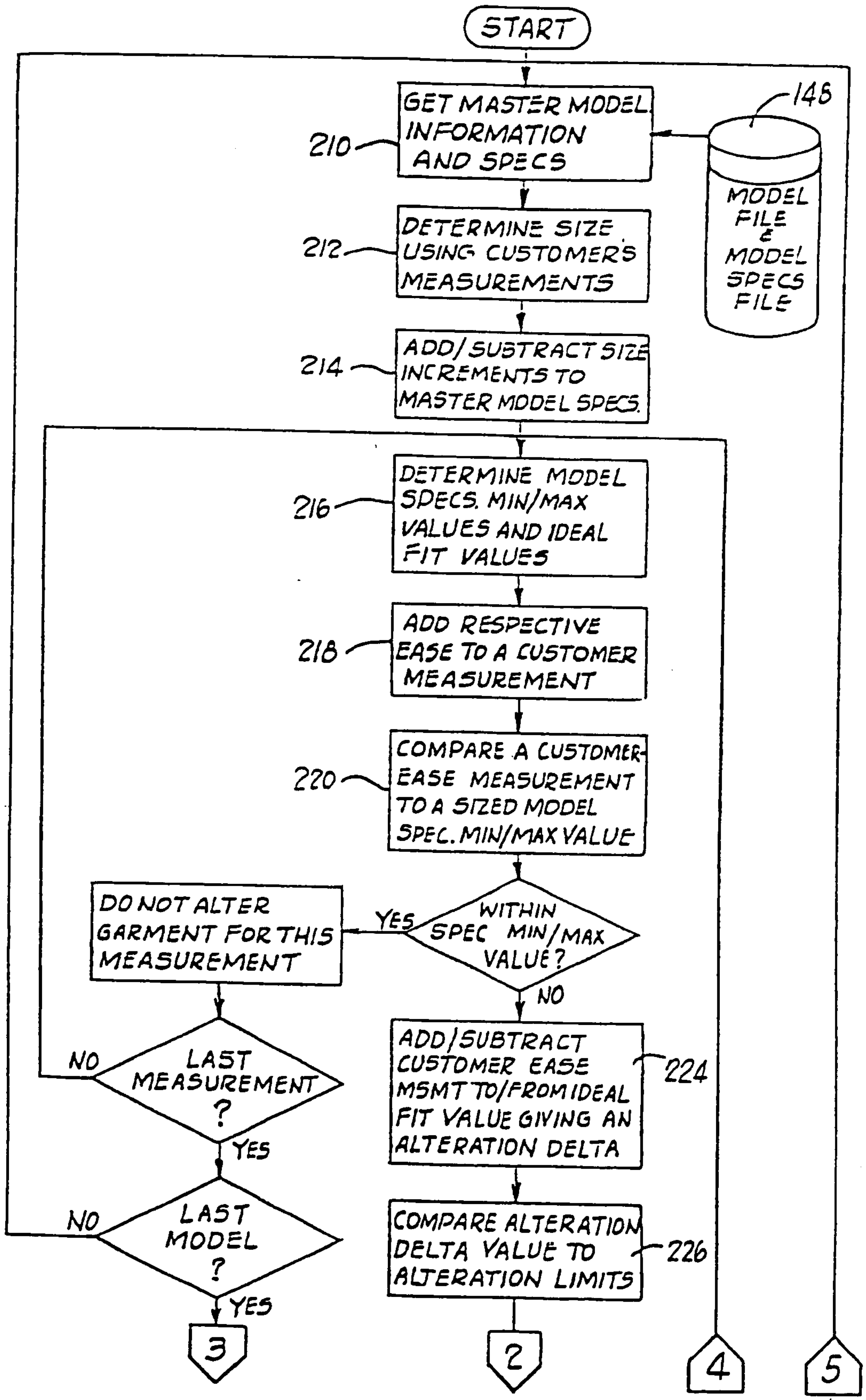

START
GET MASTER MODEL INFORMATION AND SPECS
210
148
MODEL FILE & MODEL SPECS FILE
DETERMINE SIZE USING CUSTOMER'S MEASUREMENTS
212
ADD/SUBTRACT SIZE INCREMENTS TO MASTER MODEL SPECS.
214
DETERMINE MODEL SPECS. MIN/MAX VALUES AND IDEAL FIT VALUES
216
ADD RESPECTIVE EASE TO A CUSTOMER MEASUREMENT
218
COMPARE A CUSTOMER-EASE MEASUREMENT TO A SIZED MODEL SPEC. MIN/MAX VALUE
220
WITHIN SPEC MIN/MAX VALUE?
YES
NO
DO NOT ALTER GARMENT FOR THIS MEASUREMENT
ADD/SUBTRACT CUSTOMER EASE MSMT TO/FROM IDEAL FIT VALUE GIVING AN ALTERATION DELTA
224
LAST MEASUREMENT ?
NO
YES
LAST MODEL ?
NO
YES
COMPARE ALTERATION DELTA VALUE TO ALTERATION LIMITS
226
3
2
4
5

FIG. 5A

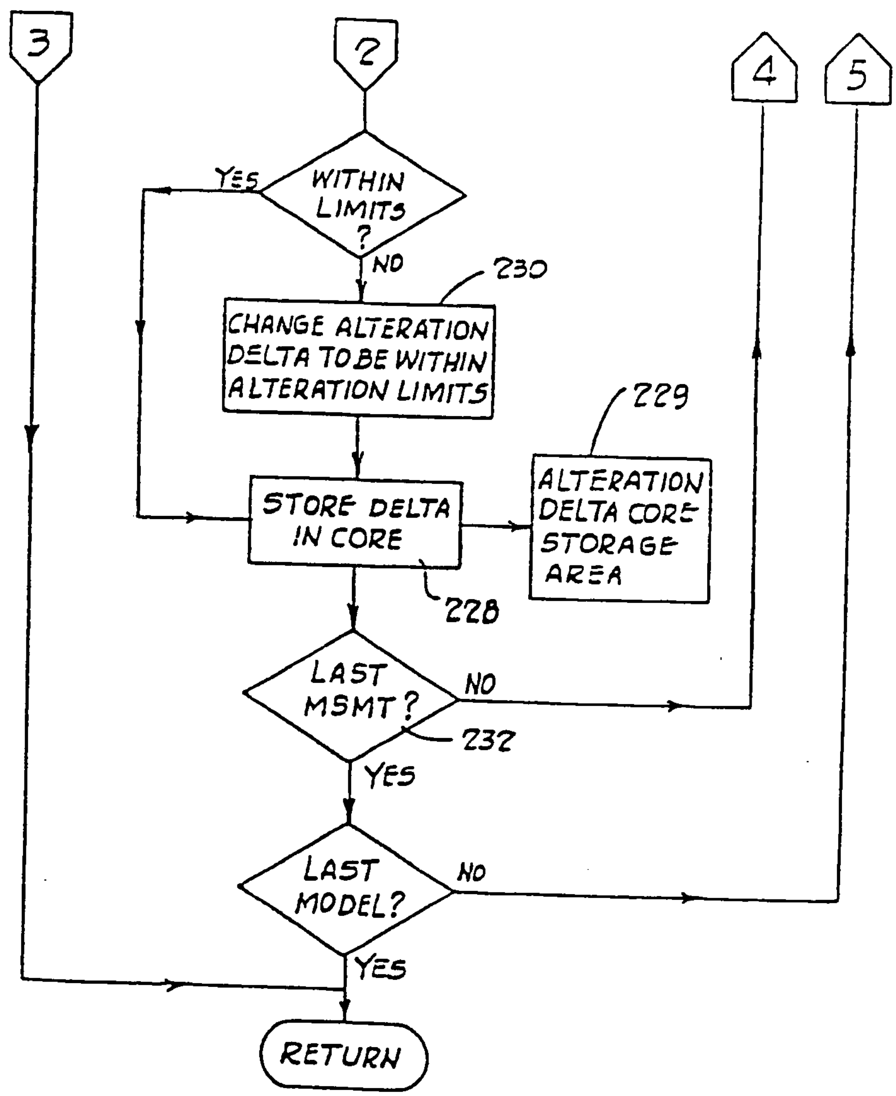

3
2
4
5
WITHIN LIMITS ?
YES
NO
230
CHANGE ALTERATION DELTA TO BE WITHIN ALTERATION LIMITS
229
STORE DELTA IN CORE
ALTERATION DELTA CORE STORAGE AREA
228
LAST MSMT ?
NO
232
YES
LAST MODEL?
NO
YES
RETURN

FIG.5B

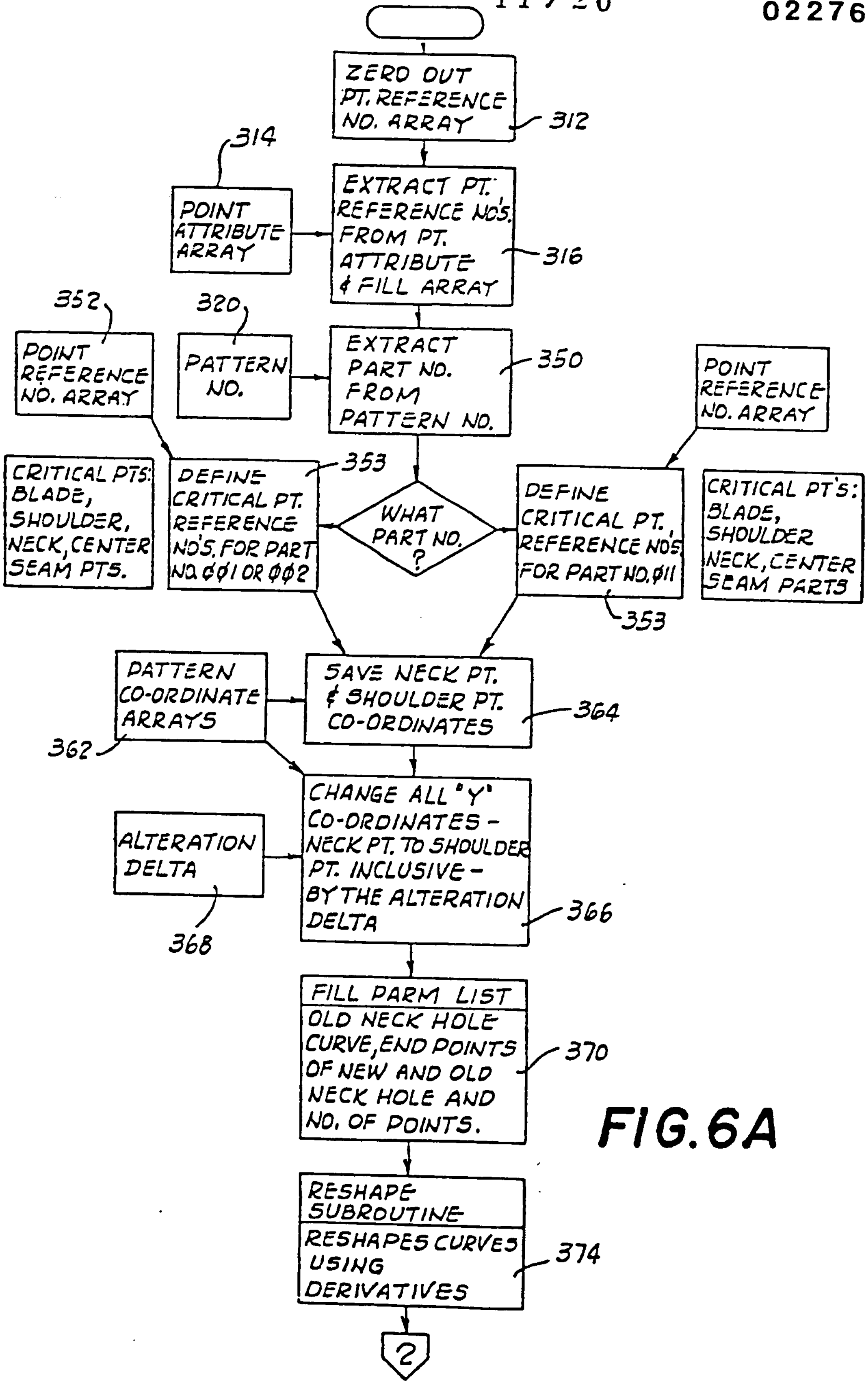

ZERO OUT PT. REFERENCE NO. ARRAY
312
314
POINT ATTRIBUTE ARRAY
EXTRACT PT. REFERENCE NO'S. FROM PT. ATTRIBUTE & FILL ARRAY
316
352
POINT REFERENCE NO. ARRAY
320
PATTERN NO.
EXTRACT PART NO. FROM PATTERN NO.
350
POINT REFERENCE NO. ARRAY
CRITICAL PTS: BLADE, SHOULDER, NECK, CENTER SEAM PTS.
DEFINE CRITICAL PT. REFERENCE NO'S. FOR PART NO. ØØ1 OR ØØ2
353
WHAT PART NO. ?
DEFINE CRITICAL PT. REFERENCE NO'S. FOR PART NO. Ø11
353
CRITICAL PT'S: BLADE, SHOULDER, NECK, CENTER SEAM PARTS
PATTERN CO-ORDINATE ARRAYS
362
SAVE NECK PT. & SHOULDER PT. CO-ORDINATES
364
CHANGE ALL "Y" CO-ORDINATES - NECK PT. TO SHOULDER PT. INCLUSIVE - BY THE ALTERATION DELTA
ALTERATION DELTA
368
366
FILL PARM LIST
OLD NECK HOLE CURVE, END POINTS OF NEW AND OLD NECK HOLE AND NO. OF POINTS.
370
RESHAPE SUBROUTINE
RESHAPES CURVES USING DERIVATIVES
374
2

FIG. 6A

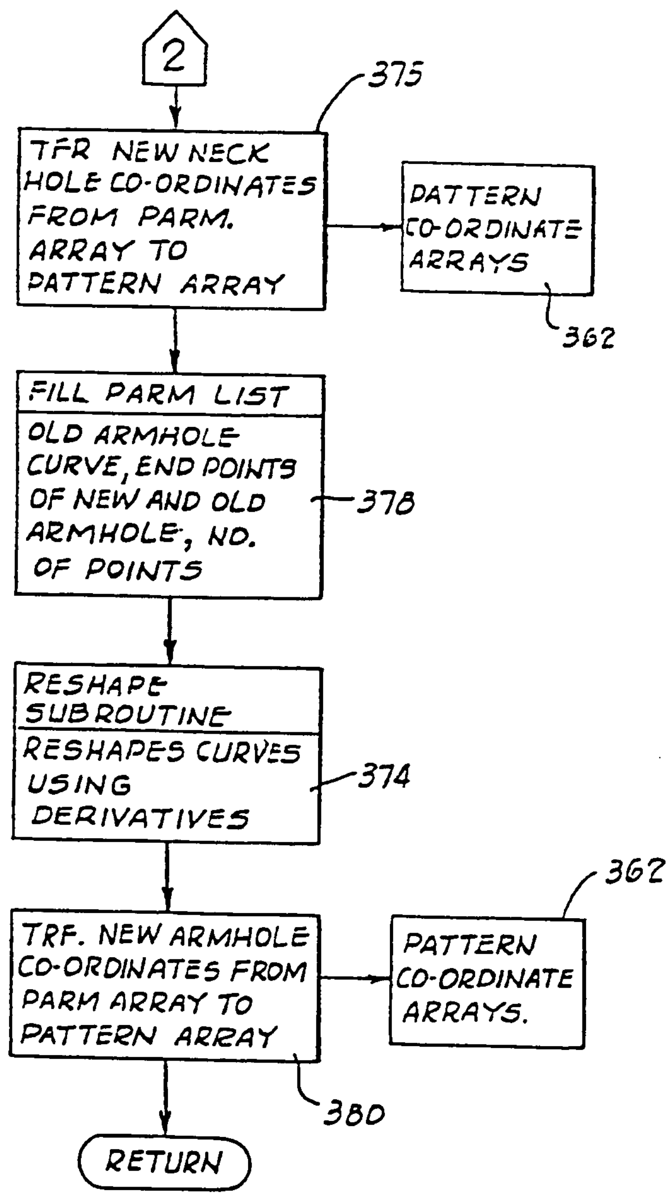

2
375
TFR NEW NECK HOLE CO-ORDINATES FROM PARM. ARRAY TO PATTERN ARRAY
PATTERN CO-ORDINATE ARRAYS
362
FILL PARM LIST
OLD ARMHOLE CURVE, END POINTS OF NEW AND OLD ARMHOLE, NO. OF POINTS
378
RESHAPE SUBROUTINE
RESHAPES CURVES USING DERIVATIVES
374
362
TRF. NEW ARMHOLE CO-ORDINATES FROM PARM ARRAY TO PATTERN ARRAY
PATTERN CO-ORDINATE ARRAYS.
380
RETURN

FIG.6B

0227642

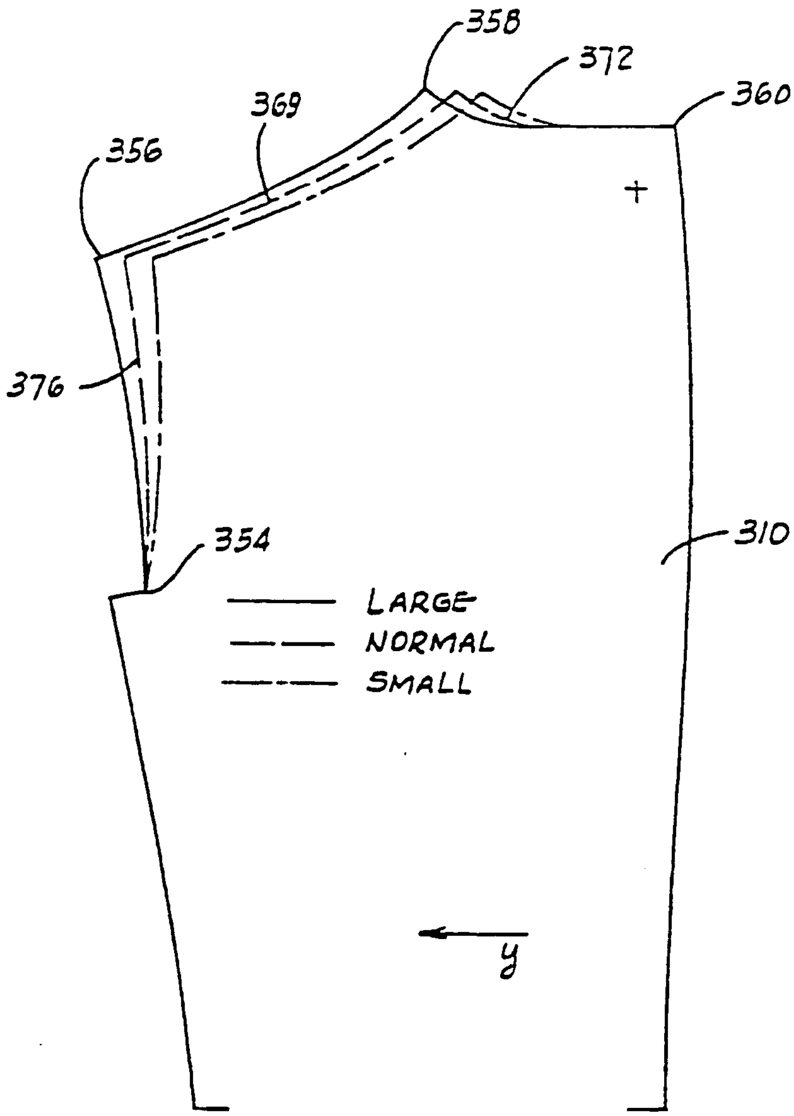


FIG.7

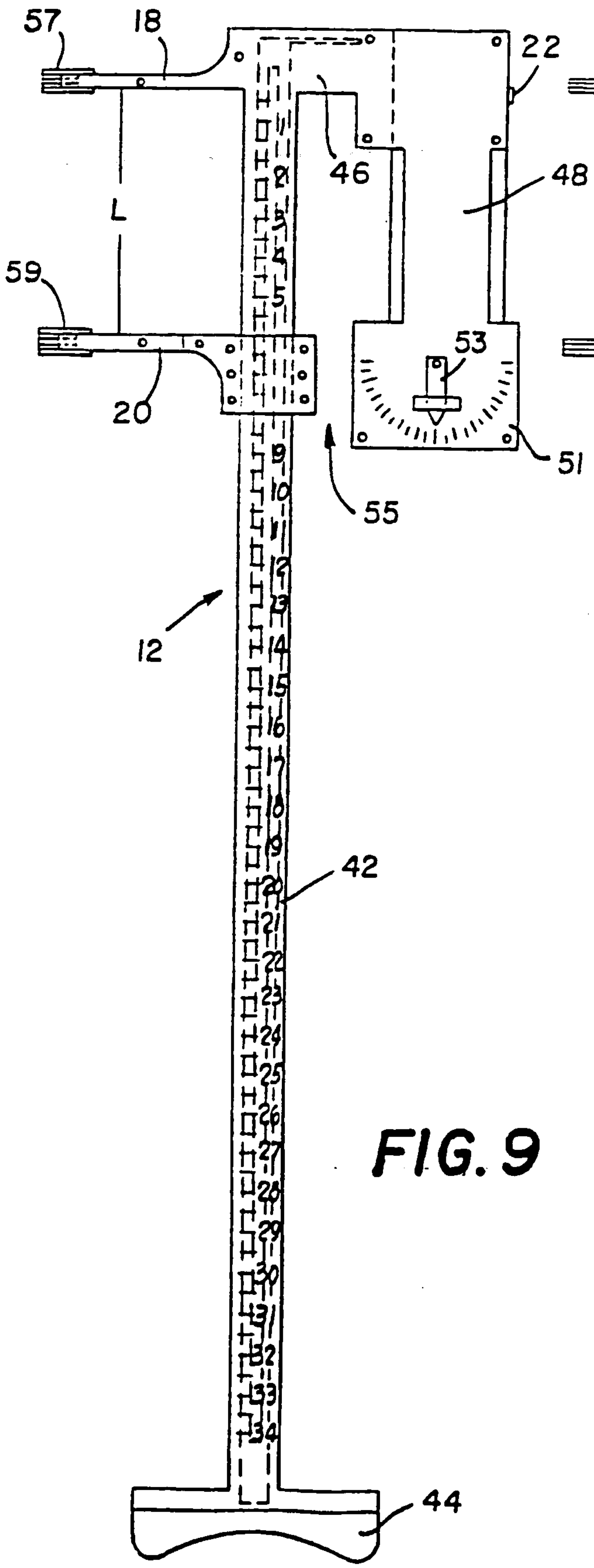


FIG. 9

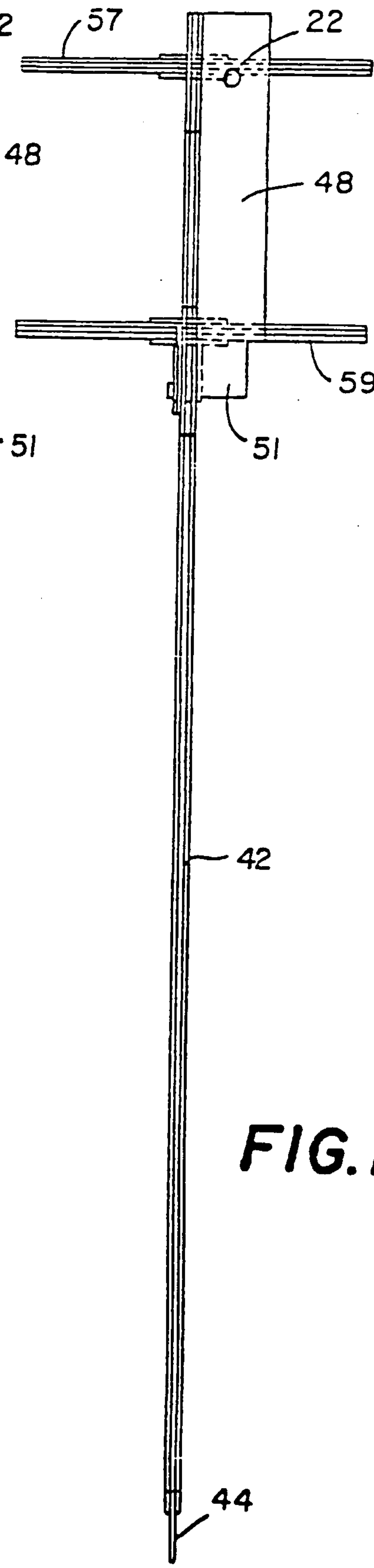


FIG. 10

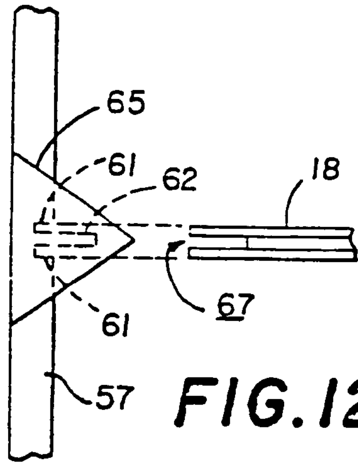


FIG. 12

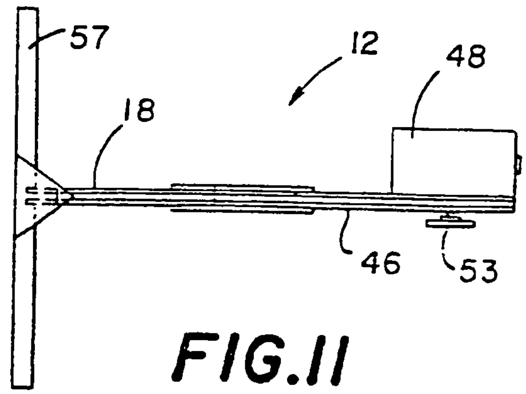


FIG. 11

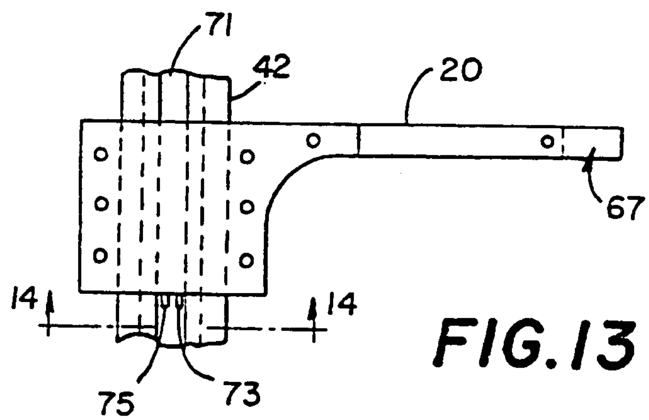


FIG. 13

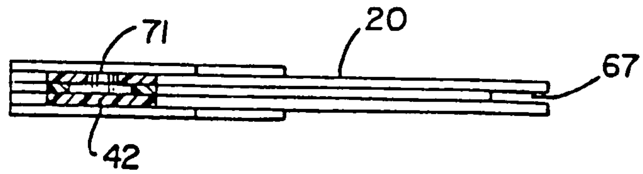


FIG. 14

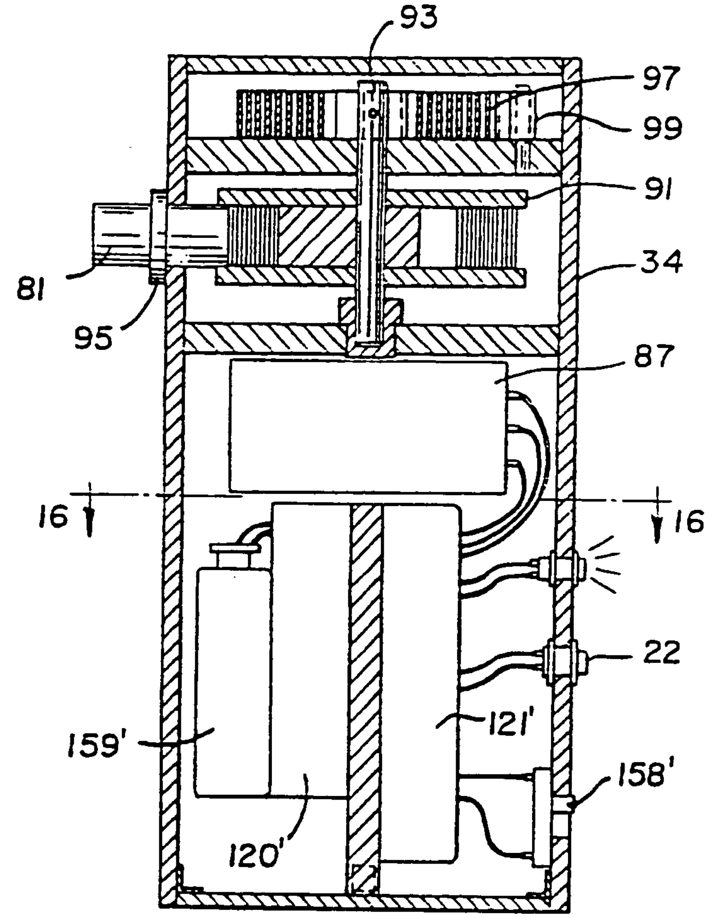


FIG.15

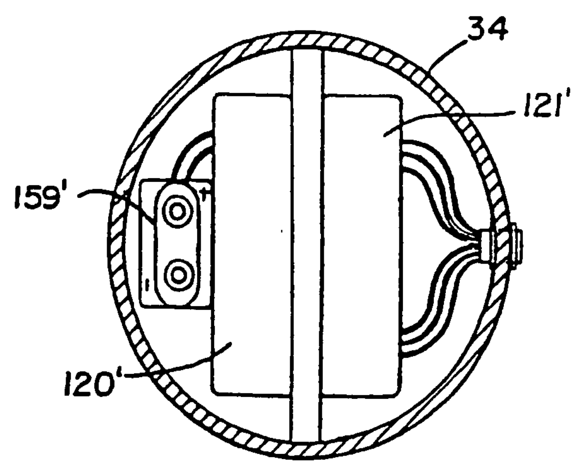


FIG.16

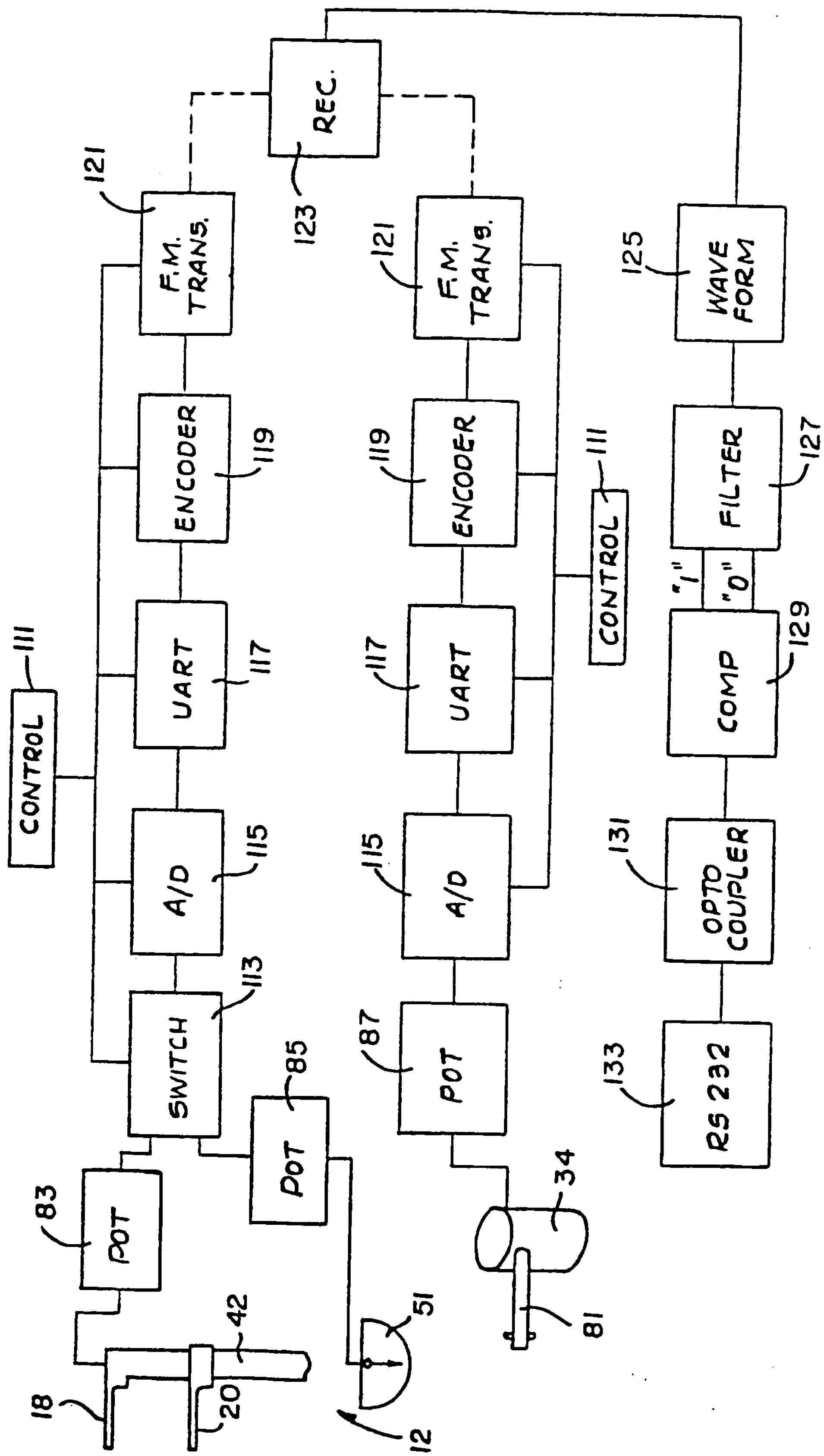

REC.
123
121
F.M. TRANS.
F.M. TRANS.
125
WAVE FORM
ENCODER
119
ENCODER
111
CONTROL
FILTER
127
"1"
"0"
CONTROL
111
UART
117
UART
COMP
129
A/D
115
A/D
131
OPTO COUPLER
SWITCH
113
87
POT
133
RS 232
POT
85
POT
83
34
81
42
51
18
20
12

FIG.17

0227642

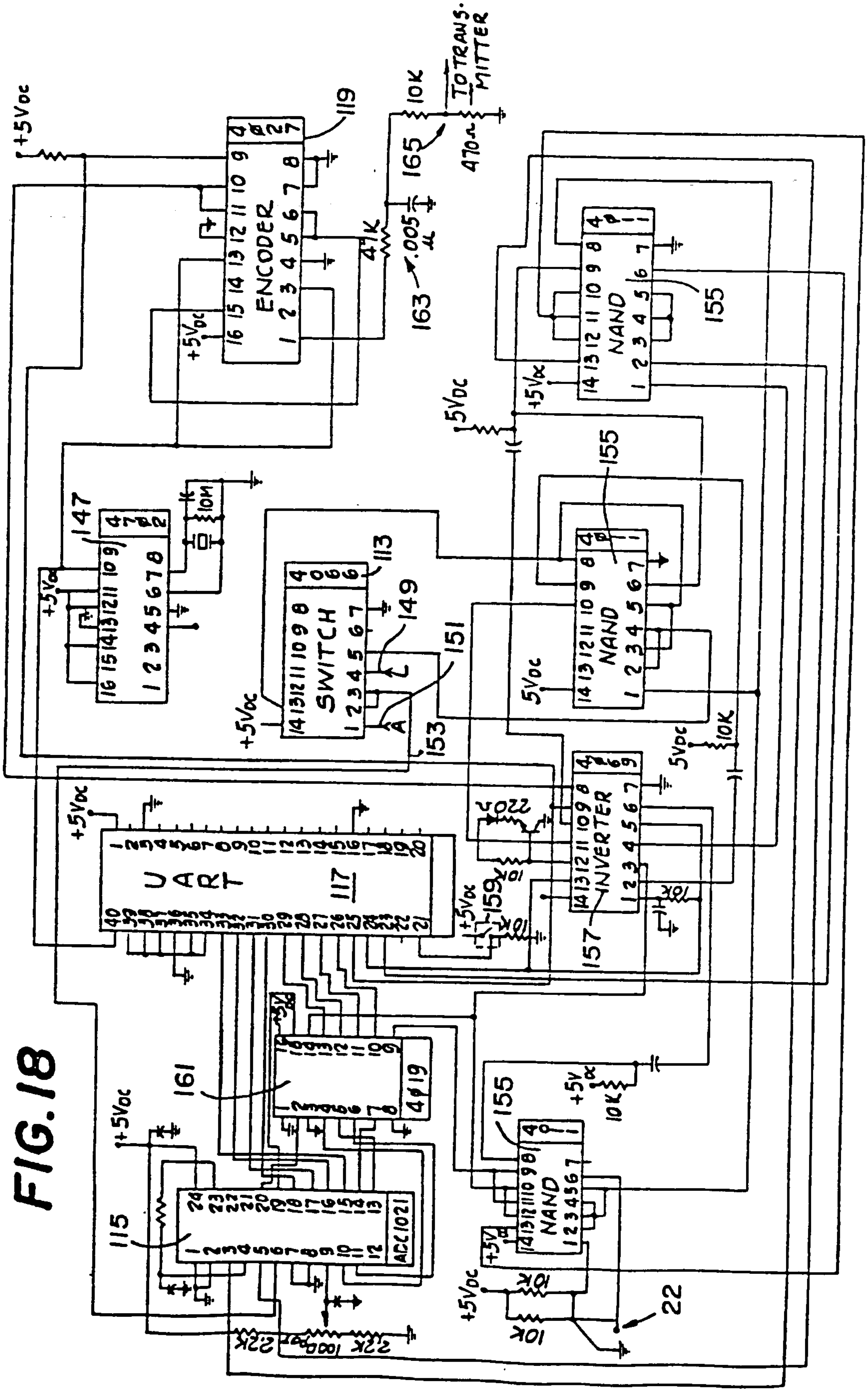


FIG. 18

0227642

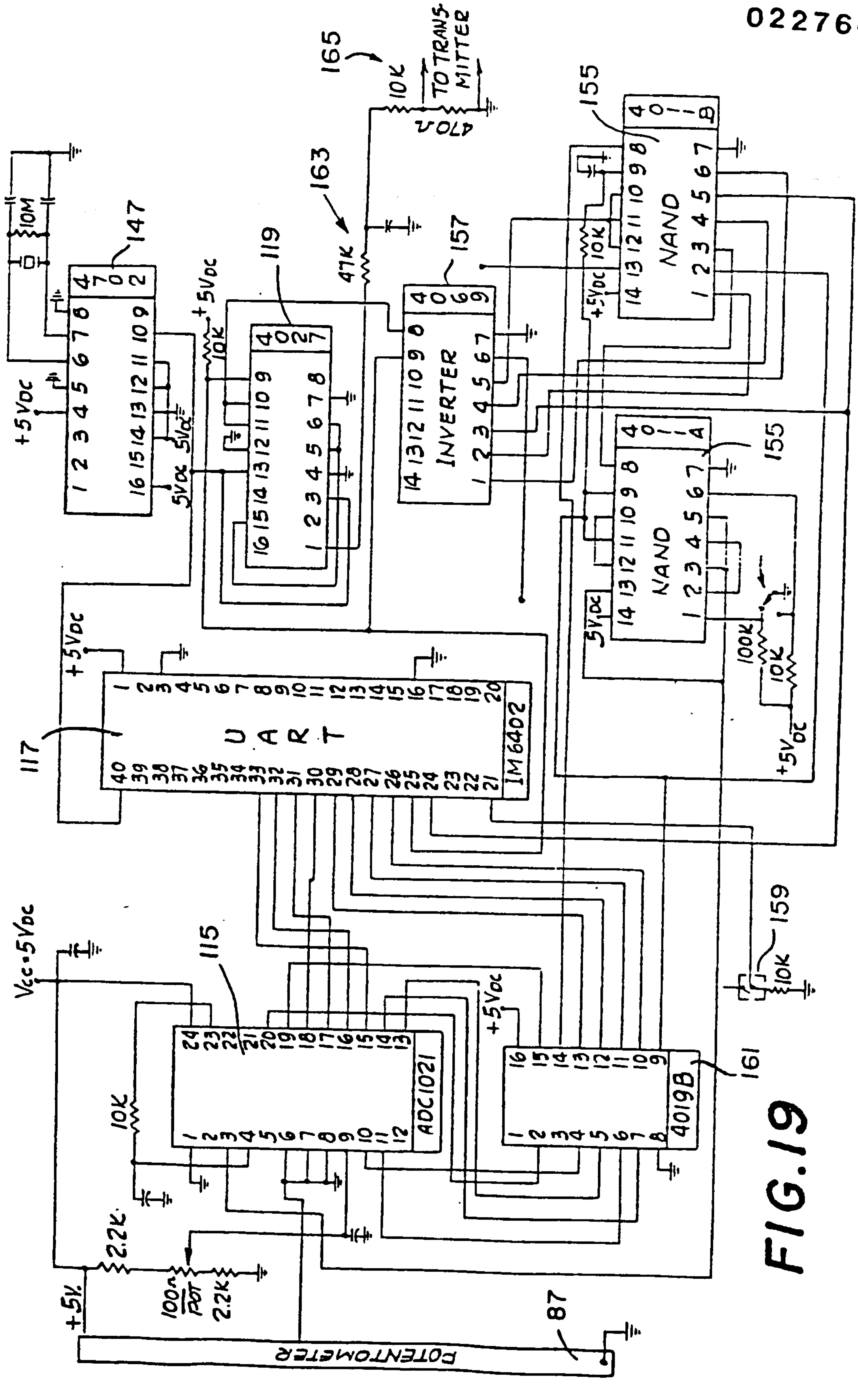


FIG.19

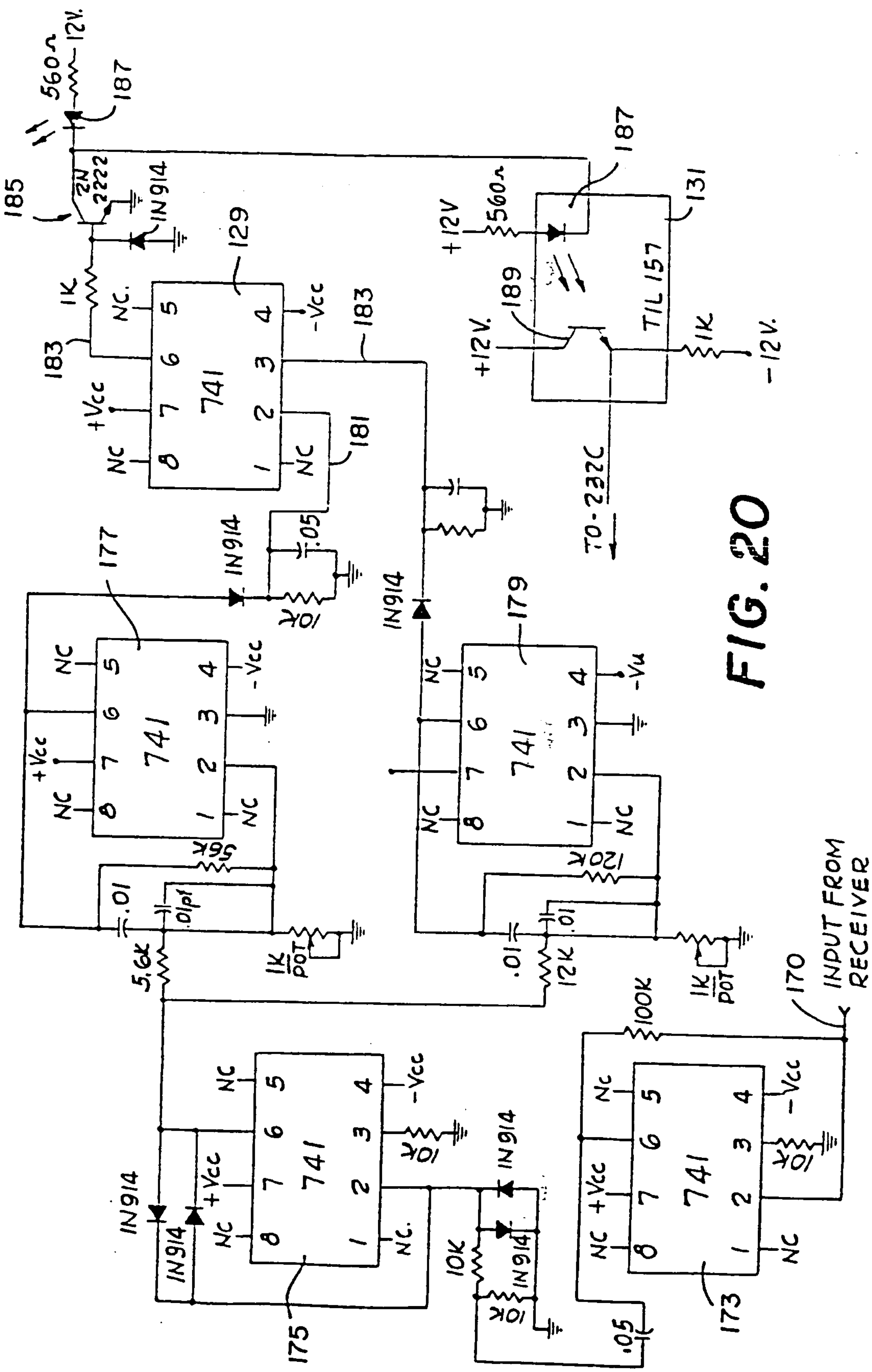

INPUT FROM RECEIVER
170
173
175
177
179
129
131
181
183
185
187
189
741
IN914
2N 2222
TIL 157
TO-232C
+12V
-12V.
560Ω
1K
10K
56K
120K
12K
100K
5.6K
1K POT
.01
.05
.01pf
+Vcc
-Vcc
NC

FIG. 20